The Boston Electrical Handbook

THE BOSTON ELECTRICAL HANDBOOK

Being a Guide for Visitors from Abroad
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PREFACE

THIS little volume is intended to set before our distinguished guests from across the sea something of the achievements of New England and of Boston, which is the educational and technical centre of New England, in the applications of electricity. Boston has been the pioneer in many successful enterprises, and has earned an honorable reputation in particular in the various branches of electrical science. It has, moreover, a distinguished reputation in the training of electrical engineers, as well as in pure science, and has furnished the capital and the brains for many successes elsewhere in the United States.

It is hoped that these pages will give at least a broad view of the technical features of interest in and about Greater Boston.

The earnest thanks of the Committee of Publication are due to the various organizations which have most heartily and enthusiastically co-operated with them in pushing this volume to completion, and particularly to a group of gentlemen, not members of the committee, who have freely and cordially given their time and labor to the work. Messrs. J. Harvey White, H. E. Reynolds, W. S. Allen, T. D. Lockwood, E. B. Pillsbury, F. E. Barker, W. D'A. Ryan, C. F. Ames, and Gen. Thomas Sherwin should receive the special thanks of the committee for their share in the task; and also the Congregational Publishing Company of Boston, for the loan of several illustrations not otherwise obtainable.

The Stanhope Press, printers, and C. J. Peters & Co., engravers, should also receive due credit for their exceptional promptness in the all-important mechanical work of transforming the manuscript into this volume.

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THE

STORY OF BOSTON

The Story of Boston

TO the visitor from across the sea, Boston presents less of novelty and perhaps more of kindred interest than any other large American city. Fifth in the list of size, it is, save New York, the oldest permanent settlement on the American continent which has succeeded in achieving a large growth, and in preserving continuously its earlier character and attributes. From the standpoint of the mother country it is a very young city, and yet its history goes back to the earliest epoch at which the Anglo-Saxon civilization had gained a foothold on the new continent. The Spaniards had settled on the south, and the French on the north, when the Cabots and their adventurous successors secured to England and all that the English heritage implies the coast that lay between Acadia and the futile and evanescent settlements in Florida.

The first permanent record of Boston and its harbor, studded then with wooded islands and surrounded by wide stretches of salt marsh, was by the adventurous Captain John Smith, cousin-in-spirit to Drake and that daring list of explorers who had gone before. Smith charted the coast, and gave to some of its salient points the names they have since retained, in 1614. Even then the hardy fishermen from England and from France were storing their ships with cod off the Banks and along the northern coast of New England; and the country, by repute, was becoming known.

Five years later came the forerunner of the movement that resulted in the founding of Boston and the permanent occupation of the northern country. The advance guard of the Puritans came, not from England, but from Leyden, and settled, by a somewhat unhappy chance, at

Plymouth rather than farther south, where they had intended to go, or farther north, in Boston, where the geographical conditions would have been more favorable to their adventure. The Pilgrims of the "Mayflower" were closely in touch, however, with their English brothers, from whom, indeed, they drew recruits at the time of their actual sailing; and it was their work, passed backward to the mother country, that resulted in the first great movement of English-speaking folk to the new continent. The first European, indeed, to explore the region now Boston and its environs, was Myles Standish, the right arm of the church militant in Plymouth, who, with some of his companions, cruised about the region in 1621.

A little later the ill-starred expedition of Sir Fernando Gorges reached these shores, backed by a syndicate of noble rank and small vital interest in colonies as such. It was a speculative operation from the start, and met the end that generally attends such expeditions in the face of the formidable task of developing a new country. It left, however, though abandoned by its promoters, a small remnant that settled here and there around Boston Harbor. Picturesque Thomas Morton, with a roystering collection of flotsam and jetsam, settled at Mount Wollaston, in what is now the city of Quincy, a spot which he called Merrymount, and proceeded to make worthy of its name in a fashion that shocked the God-fearing men of Plymouth, and brought Captain Myles Standish, with his soldiers, again toward Boston, bent on an errand of effective suppression. On an island in the harbor that still bears his name was settled, with his family, Thomas Weston, one of Gorges' attorneys, perhaps cherishing a forlorn hope of holding the country for his client. On Noddle's Island Samuel Maverick, another of Gorges' party, founded a home; and Walford, a blacksmith, preempted the near peninsula, now Charlestown.

The first settler in the city of Boston proper was still another who shared the fortunes of Gorges, — William Blackstone, a graduate of Cambridge University; a

strange, shadowy figure, who dwelt in a lonely home on the western slope of what is now Beacon Hill, looking out over the wide meadows of the Charles.

But these were strays and wanderers. In 1629 began the real influx from England. A strong body of the sturdy Puritan stock from around old Boston, with a powerful and wealthy backing of influential commoners, obtained a royal charter and set forth, not merely for adventure or trade, but for the founding of a colony. They were grim reformers, these Puritans, whom opposition at home and despair of carrying out a scheme of universal and drastic reform had turned regretfully away from their native land to form a commonwealth after their own hearts in a newer England. They came in 1630, after sending an advance party that settled at Salem under John Endicott, a thousand strong, under the leadership of John Winthrop, and landed at first in Charlestown. They were of the stuff that conquers nature and builds up commonwealths; and Winthrop was a type of the leaders who have made the Anglo-Saxon race supreme in many a hard-won land.

Of these and by these was created Boston and the country that has grown to be the guardian of Anglo-Saxon civilization in the West. From the first the colony bore with it the elements of permanent success. Its task in winning the country was much lighter than that which has fallen to the lot of most colonies, for, by a curious chance, the aborigines in this locality had already, even before the coming of the Pilgrims, been for the most part swept away by internecine strife and by pestilence, probably small-pox or measles acquired from the visiting fishermen; so that of savage opposition there was practically none in the vicinity of Massachusetts Bay.

The centre of the colony soon became the hill-studded peninsula which is the nucleus of the present Boston. It had been known to the Indians as Shawmut, but the colonists bestowed on it and on the later settlements about it the names of their loved home towns. Here they built their village and set up their government,—a popular government, woven around the church which

they had crossed the seas to preserve and maintain. For more than half a century Massachusetts was practically an independent nation, under the direct government of its founders and their successors; and in that period Boston had grown to be the most active and important settlement on the American coast. It was preeminently a trading and sea-faring community, the base of supplies for the large fishing interests, and the commercial centre of the new world.

With popular government and their sturdy church the Puritans linked, from the very first, provisions for popular education. They had hardly formed their settlement before they appointed Philemon Pormont a schoolmaster, — the first of that long line of New England schoolmasters that has kept up the supremacy of letters through all the stress of building up the nation. Six years from the time when Winthrop and his party set foot on land, they founded Harvard University, which still remains the most notable, as it was the first, institution for higher learning on the continent.

As the settlers went out into the surrounding wilderness, axes in hand, the town-meeting, the church and the school went with them; and in 1647, by a general law of the Commonwealth, it was enacted that every township "which the Lord hath increased" to fifty householders should appoint from their number a schoolmaster, and that when the number of families reached a hundred they should set up a "grammar school" capable of fitting youth for the university. The school was part of the Puritan policy, and it has gone with the descendants of the Puritans from Boston to the Golden Gate, until every town in the three thousand miles that lie between is marked by a towering school-building, conspicuous to all comers, and bearing still the mark of the Puritan desire for and policy of education.

The settlers of Massachusetts were English to the core; and English their descenadnts have remained to an extent unusual in a country swept over by great tides of immigration in succeeding generations. Boston, a half-century after the founding of Harvard University,

was characteristically an English town, with the traditions of the old home still strong about it. It had then come to be a town of about six thousand inhabitants, and already the colonists had begun to stretch their bounds by grasping land from the sea. In the beginning Boston had been a peninsula, connected with the mainland by a narrow neck nearly a mile long, and so low that great tides now and then swept over it. It was margined by tidal marshes, through which Long Wharf, at the foot of State Street, the city's financial centre, then King Street, was later built out 2,000 feet to accommodate the larger commerce. The whole peninsula included but 783 acres, an area which has been much more than

Paul Revere's Map of Boston

doubled by the reclamation and filling of the marshes, on which stand to-day the principal residence and some of the largest commercial districts of the city. The old sea line swept through the western part of what is now Boston Common.

The jurisdiction of Boston in those early days included a large part of the outlying country, later cut up into the towns and cities which go to make up what is known as Greater Boston, and some of which have since been reclaimed by the old city.

By the latter part of the eighteenth century Boston had risen to be a compact and well-built city of some 25,000 inhabitants, decidedly the most important city

upon the coast, although later far outstripped in size by New York. To-day it has grown to be a city of some 560,000 inhabitants, covering nearly 43 square miles of territory, and embracing within its tributary region of Greater Boston nearly 40 cities and towns with an aggregate present population of nearly 1,200,000 people. Boston proper has no technical jurisdiction over these, but they are welded into a whole by situation, by common interests, and by common organization for certain public purposes. The Metropolitan Parks district comprises the region as a whole, and includes 38 cities and towns; the Metropolitan Water district includes 17; the Metropolitan Sewerage district, 24; and the Boston Postal district, 10. In a sense, therefore, the outlying cities and suburbs are now, in fact, as they were and always have been by origin, condition, and spirit, a part of one great municipal community.

Boston has been waggishly defined as "not a locality, but a state of mind;" and it is the pride of Boston and of Massachusetts that this state of mind is the heritage from Winthrop and his followers, who brought with them to the new England the best traditions of the old. To-day Boston is the fifth city in population in the United States; in financial and commercial importance it takes a much higher rank. Once almost exclusively a city of shipping and shipping interests, the wealth which it thus accumulated has gone out into new fields of endeavor, and its quickening touch has been felt throughout the country. From this impulse came, on the very outskirts of Boston, the first railroad built in the country; the beginnings of the cotton industry; and many another enterprise that has added to the wealth of the nation.

Structurally there is little left of the older Boston. Time and again it has been swept by fires, and to-day only scattered buildings remain as relics of the colonial period. The Old State House, the centre of government in colonial days; Faneuil Hall, enlarged nearly a century ago out of all semblance to its former self; the Old South Church, in the wooden predecessor of which Benjamin Franklin was baptized, and next door to which

stood the house of John Winthrop; King's Chapel, the first permanent home of the Established Church of England in the colony, now long dispossessed of it; and a few other venerable buildings,—are all that is left of colonial Boston's brick and stone.

The Old State House

Modern Boston is a well-built city, architecturally distinguished from others of its size mainly in being rather better kept up as to its general appointments, and

in possessing, outside the limits of the old city, perhaps the finest group of residential suburbs to be found on the continent. The growth of suburban life is favored, in spite of the peninsular character of old Boston, by the general topographical situation, with fine rolling and hilly country stretching for miles about the city, and by two rivers, the Charles and the Mystic, the former of which winds in a peculiarly sinuous course among the western suburbs, lending a special charm to the landscape in the environs of the city. Boston is favored, too, in possessing what is very unusual in cities of its class, — a considerable park, formed by the ancient Common and the Public Garden, later added to it from reclaimed land, in the very heart of the city, touching, indeed, the business centre; and, besides, in the wonderfully beautiful and diversified park system, under the control of the Metropolitan Park Commission, giving to suburban Boston, as well as the city proper, an exceptional group of parks, unusual both in size and in beauty.

Boston is also favored by having its varied suburban districts kept in close touch with the centre of the city both by a considerable number of suburban steam lines, and by what is probably the most effective electric car system in the world, presently to be described at greater length. These advantages have favored the growth of the city in a very remarkable degree, especially within the last decade.

In public and semi-public buildings and institutions Boston is particularly rich, and especially so in institutions of learning, old and new. The Boston educational system, of course, centres around its ancient Harvard University, later to be described at some length. Modern technical instruction is represented nowhere in the country by a more worthy example than the Massachusetts Institute of Technology, resting largely upon a public foundation, though aided by private benefactions, and which for nearly forty years has held a commanding position in the study of applied science. Its special facilities are worthy of description by themselves. In addition to these, Greater Boston possesses a note-

worthy group of less widely known but most efficient institutions of high collegiate grade, which for years have done efficient and distinguished work. Boston University, Boston College, and Tufts College are large and well-administered sectarian institutions, doing both undergraduate and graduate work. The last mentioned has devoted more than usual attention to modern engineering courses, and has done a large and praiseworthy work in furthering modern education as distinguished from the old academic lines. Of these three, Boston University and Tufts College are co-educational institutions.

Public Library

There are, too, three important colleges for women: Wellesley, in one of the most beautiful outlying suburbs, founded in 1875, and long noted as one of the most important of its class; Radcliffe College, which has been built up under the wing of Harvard University, and now grown to important dimensions; and Simmons College, recently founded, and forming, in a sense, a women's technological school for instruction in such branches in art, science, and industry as will best enable women to earn an independent livelihood. To these must be added a considerable group of higher schools, preparing for the universities, and giving special and professional training.

Quite co-ordinate with any of these institutions in its bearing upon public education is the Boston Public Library, long the pride of the city, and unique in its intimate relation to the citizens as individuals. It occupies now a severely beautiful quadrangular building on Copley Square, covering an acre and a half of ground, exclusive of the great central court. The interior is rich in mural decorations by famous artists. It has a splendidly administered set of reading-rooms for general, special, and technical work, and contains now

Main Stairway, Boston Public Library

about 900,000 volumes, thus placing it among the world's great libraries in point of absolute size. It is a true circulating library, free to every citizen of Boston for the withdrawal of books, and for reference to all comers without the slightest formality. It maintains 10 branch libraries scattered over the city; 22 free delivery stations, of which 14 are reading-rooms as well; and a large number of points at which there are regular deposits of books, including all the public schools. In the total there are

157 direct points of contact between the public and the contents of this great library. It is by far the largest actively circulating library in the country, and in fact the largest in the world. Besides this enormous local work, in which a million and a half volumes are annually circulated, it carries on an extensive educational work by free lectures and special exhibitions. The extent to which it is popularly used is best shown by the fact that it has out about 75,000 regular and special cards, which means that about 15 per cent of the population actually use the library for the home reading of books.

A minor but most interesting function of the library is an informal system of interlibrary loans by which books actually needed for serious research can be loaned to or borrowed from other libraries in New England, or even in the country at large. Such a privilege is necessarily rather carefully guarded, but its value is self-evident. This feature of American library service, by the way, has now developed to a considerable extent, so that it becomes possible for scholars located near any large centre, to command, in case of need, the aggregate resources of most of the great American libraries. Including college and society libraries, the Boston student can obtain, if necessary, access to more than 2,000,000 volumes in the immediate vicinity.


Trinity Church

On Copley Square also is situated the great Museum of Fine Arts, which ranks above any similar institution in the country, particularly in some of its departments; and Trinity Church (Protestant Episcopal), a fine example of modern ecclesiastical

architecture. Here, too, stand the older buildings of the Massachusetts Institute of Technology and the Natural History Museum, containing a library and important collections.

Of other public enterprises perhaps the most noteworthy is the City Hospital, located in the South End of Boston, one of the best organized and administered institutions of its class in the world.

The Puritan impulse in popular education has surely not been lost in the later years of Boston's development, spurred on by a great group of notable men in education, literature, and art, and the whole Boston region has produced more than its share of commanding figures in the intellectual world. Here Prescott, Motley, and Parkman, historians, carried on their life-work. Here Ralph Waldo Emerson preached, and later, in retirement, studied and wrote. Here Hawthorne wove his matchless romances. Here Longfellow and Lowell and Holmes lived and wrought Here, too, Edgar Allan Poe was born.

Aside from pure literature, Boston has been pre-eminently, as might be well imagined from its history, the home of aggressive reformers. It was the centre of the anti-slavery movement that with gathering force eventually drove out the greatest blight on the western civilization. Here, in protest against the older theology, arose the spirit of Unitarianism, and many another movement that has done its share in shaping the world's thought.

In pure science, too, Boston and its environs have a distinguished roll of names, beginning with Benjamin Franklin, who was born here nearly opposite the Old South Church. Near there also was the early home of Benjamin Thompson, Count Rumford, who later won permanent fame as the pioneer in the dynamical theory of heat. S. F. B. Morse, the father of telegraphy, here was born and passed his youth. Asa Gray, the botanist, and Agassiz, did their life-work at Harvard. In mathematics, Nathaniel Bowditch, of "Navigator" fame, was a commanding figure in the early part of the last century; and following him, the Pierces, father and son. In astronomy, the Bonds, father and son again, gave to that

science its first vital movement in this country; and their worthy successors, the Pickerings and Chandler, have carried on their work at Harvard up to the present. In connection with them should be mentioned Alvan Clark and his two distinguished sons, builders of many of the world's great telescopes.

King's Chapel

In the middle of the last century Boston was the scene of Morton's immortal experiments in anæsthesia, and the first operation under ether was performed by him in the Massachusetts General Hospital, a great institution still distinguished in the annals of surgery.

And in applied science it should not be forgotten that Boston was and is the home of telephony; for in the laboratories of Harvard and the Institute of Technology, Graham Bell worked out what should probably rank as the greatest single time-saving invention of modern times, and the telephone industry has had here its permanent centre. Boston, too, was the first large city to adopt electric traction, and one of the earliest homes of incandescent lighting.

Of these later achievements it is the purpose of this volume to speak in suitable detail, and to set forth the practical importance of the engineering sciences in the service of modern life

Electrical Boston

MASSACHUSETTS, the original seat of popular government on this side of the Atlantic, has developed its principles in many interesting ways, in nowise more effectively shown than in dealing with the problems which arise in connection with the administration of affairs in a metropolitan community like Boston. The principle underlying the administration of government in this Commonwealth, seems to be the direct dealing with public affairs in the interests of the people. To this end, the referendum is a measure very frequently employed, particularly in the metropolitan districts, where public questions are submitted to the direct franchise.

Another manifestation of the same direct and informal method of action is in the granting of large powers to Commissions dealing with various matters of public importance, and coming into direct touch with the parties to discussions on these matters. Although the authority granted to these special Commissions might seem, at first sight, a step away from popular government, the closeness of their relation to the interests put in their charge enables the public feeling and the public wishes to be expressed clearly and forcibly to those who have authority to act. The result of granting governmental powers to those Commissions has, upon the whole, been very happy. The Metropolitan Park Commission and the Metropolitan Water Commission, and the rest, have been able to effect notable improvements with the minimum of fruitless friction, and with a promptness almost impossible to attain by any other means.

Especially in dealing with the quasi-public corporations in their relation to the cities of the Commonwealth these commissions have been invaluable. Two of them, the Railway Commission and the Gas and Electric Light Commission, come in close touch with electrical enterprises. A brief view of the functions and operations of the latter of these organizations will give a clear idea of the way in which they practically operate, and the useful end which they serve in protecting both corporate interests and the rights and privileges of the public at large. It has proved possible to secure for service on these various commissions, men of high judicial character and unquestioned integrity, who have given to the unusual bodies which they constitute much the same reputation for efficiency and integrity that has long made the Massachusetts judiciary distinguished.

The Board of Gas and Electric Light Commissioners

THE Board of Gas and Electric Light Commissioners was organized in 1885 under authority of a legislative act of that year. It originally had under its authority only gas companies, but in 1889 its supervision was extended to electric light companies, and it has the same powers respecting both classes of corporations. It consists of three men appointed by the governor of the Commonwealth, with the approval of the council, each for a term of three years, and the terms are so arranged that one appointment must be made every year. The expenses of the commission are paid by the State, but are recovered annually from the companies by a special tax levied upon them in proportion to their respective incomes.

Originally the board was given a general supervision over the companies, and was to secure their compliance with such restrictive legislation as might be in existence with respect to them. All companies were required to make annual returns in the form prescribed by the board, and to keep their books and accounts in such manner as the regulations of the board should determine.

In any city or town in which one company was in operation no second company could undertake the supply of the same kind of light, except after a public hearing before the local authorities, from whose decision an appeal might be made to the board of commissioners, whose decision upon such questions was final. The board had also authority, upon petition of the local authorities or twenty customers of the company, to fix the price for gas or

electric light, after notice to the company and a public hearing. It had authority too, after public hearing, to compel companies to supply a would-be customer with gas or electric light.

All these powers have been continued, but from time to time the Legislature has had occasion to require from the board special reports upon matters of unusual perplexity which apparently called for remedial legislation; and by first obtaining from the board the pertinent facts and its opinions, too hasty and ill-considered legislative action has frequently been avoided.

In 1891, the Legislature empowered municipal corporations, under certain conditions, to undertake the supply of gas and electric light, but gave the Board of Gas and Electric Light Commissioners certain supervision over those towns and cities which should take advantage of this law. Such municipalities are accordingly required to keep their accounts and make annual returns in such manner and form as the board may require. In this way more definite and reliable information relative to these enterprises has been secured in Massachusetts than any other of the United States. Except in respect to their accounts and the exhaustive data which municipalities are required to furnish relative to the business, the authority of the board over them is very largely advisory in its character.

The most important extension of the board's power since 1891 was in 1894, when it was given authority to approve the issue of all new securities, whether stock or bonds, and companies were prohibited from issuing such except upon the approval of the board. The policy of the board in its administration has been to prevent any watering of the stocks of the companies under its supervision, and, to a remarkable degree, to prevent the securities of any company exceeding the fair structural value of its plant. As stated by the board, "This act and the purposes which underlie it imply no hostility to corporate powers, and it is the duty of the board in administering it to conserve, so far as it may, the interests of both the stockholder and the public. So far as it may

properly be done, the board should encourage and assist investments made for the performance of a needed public service rather than embarrass or injure them. The interests of the public and the stockholders alike are best conserved by a policy which will give permanency and security to capital thus employed." This statement affords a fair indication of the general spirit and policy with which the authority intrusted to the board has been exercised.

Subsequently, the board was authorized, upon finding the capital of a company impaired when approving new securities, to require the company to make good such impairment in the way designated by the board. Under this, companies have in rare cases been required to restrict their dividends in order that larger sums might be available out of earnings, or to call in surplus capital.

Under its general supervisory powers the board has in a great number of cases been called upon to arbitrate between companies and customers upon matters not specifically mentioned in the statutes; and while these cases have not been regarded by the board as of sufficient importance to be described in its annual reports, this course has contributed in a very large measure to establish satisfactory relations between the companies and the consumers.

The board makes an annual report to the Legislature which gives an account of its doings, exhibits to a very large extent the financial affairs of all the companies, and contains extensive and detailed technical information with respect to them. This report is printed by the State, and finds its way practically to all portions of the world where active interest is taken in the supply of gas or electricity for public use.

In accordance with the usual Massachusetts policy of re-appointing efficient public officers, most of the men who have been members of the board have served for several consecutive terms. The present chairman has occupied that position since 1894, and has been a member of the board from its beginning. Another one of the members has served for more than ten years. By this policy the

board has come to be practically a commission of experts upon the subjects under its control, and its administration has been entirely free from political or party influence of any kind. Its purpose has been to deal with business questions in a purely business way, seeking thus to secure fair treatment for the public and a liberal measure of success to the corporations while properly managed.

At the date of its last report, the board had under its supervision 145 private and 18 municipal corporations. Of the companies, 48 are engaged in the supply of gas only, 25 in the supply of both gas and electric light, and 72 supply only electricity. Of the municipalities, 4 have plants for the supply of gas and electricity, and the other 14 supply electricity only. The total amount invested by these corporations is about seventy-five million dollars, and their gross income for the year ending June 30, 1903, was about seventeen and one-half millions.

The Railway Commissioners, a board similarly organized, and with powers almost equally large, has proved effective in guarding the interests of the community in its dealings with steam and electric railways, and in giving to these corporations a character for conservatism and stability which has, in the end, proved of high value both to them and to the Commonwealth.

With many of the problems of corporate rights and privileges in the metropolitan district, the Legislature deals somewhat directly, and, fully realizing the peculiar interests of a great metropolitan district, it has not hesitated at any step which would improve the rapid transit facilities about Greater Boston, and which would give to the metropolitan district prompt relief in any exigency. The city of Boston proper has been active in furthering the interests of the community of which it is the centre, and in perhaps nothing more than in rapid transit has it successfully co-operated with the Commonwealth and with private corporations. The electric railway has been of unique value to the city of Boston, in welding together the city and its suburbs into a coherent community. At the present time, the rapid transit of Greater Boston, developed rapidly by the springing up of local

enterprises, has, in great measure, been unified, and has come to be largely in the hands of a very few important corporations. Chief among these is the Boston Elevated Railway, which forms the centre of the great radiating network of electric lines, largely under its own control in the nearer suburbs, and connecting with the lines of other companies beyond.

THE BOSTON ELEVATED RAILWAY COMPANY

The Boston Elevated Railway Company

UNDER the control of this corporation, Boston has one of the best and most interesting street railway systems to be found on the continent.

It would not be characteristic of Boston if it did not itself possess some points of historical interest. Here the trolley car was first demonstrated to be suitable for operation in a large city, and it is largely due to the vast sums spent in determined experimentation by the West End Street Railway Company that electricity was made a practical motive power for street cars. Here the first subway for tram cars was built. Here is found the first and only existing street railway service in which surface, underground, and elevated lines are combined in a single comprehensive system, operated so that all the various lines and different kinds of service are made co-operative.

Strangers who have no technical knowledge are chiefly impressed with the extensiveness and convenience of the service. The payment of a single 5-cent fare enables a passenger to reach practically any point within the area of one hundred square miles served by the company. Free transfers are given at convenient points, not only between the various surface lines, but between the elevated, surface, and underground lines whenever necessary. It is possible to ride a distance of 20 miles for 5 cents. The politeness and efficiency of the employees engaged in the car service is particularly noticeable and welcome to the visitor.

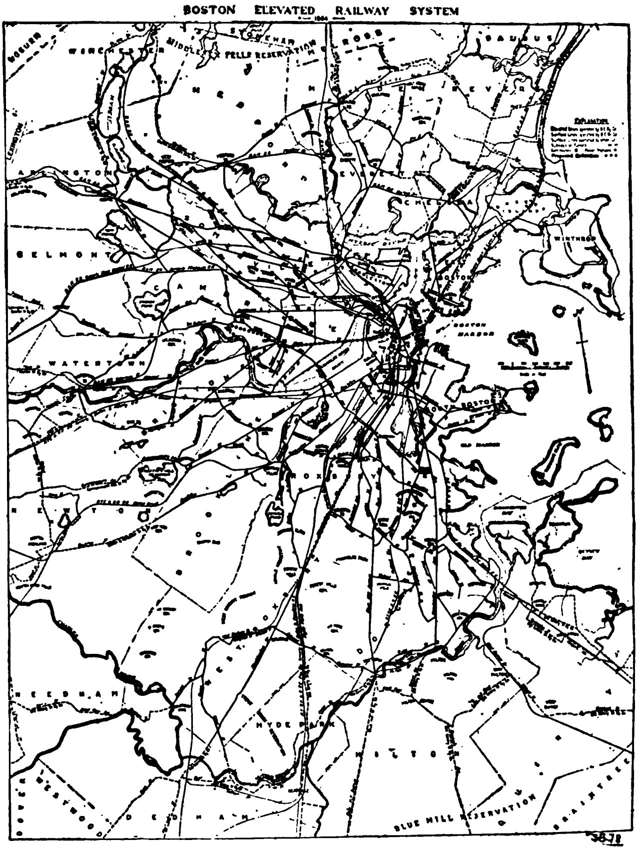
The features of technical interest are even more numerous and important. The topography of the city, its narrow and crooked streets, the large volume of traffic to be handled, and the scarcity of highways available for that

purpose, all combine to produce problems, the solution of which tax the ingenuity of operating officials to the utmost. The company's system of numerous scattered power stations, instead of one central plant, has resulted in an economy and excellence of service that will surprise many of the advocates of the single station idea. The system of automatic block-signals is said to be the most complete and efficient in existence, and has amply proved its efficiency by giving complete immunity from accidents. The elevated and subway structures, the plans for the development of the system to provide for future growth, the exceptional excellence of road-bed, tracks, special work and equipment, is worthy of careful investigation and study. The system of selecting, training, and disciplining car service men has resulted in the production of so exceptional a corps of street railway operatives that it will be found highly suggestive and valuable to all who are required to manage large numbers of organized men.

THE UPBUILDING OF THE SURFACE SYSTEM

Street cars have been operated in Boston for more than fifty years, but it was not until 1887 that steps were taken to adapt the street railway service to the needs of the metropolitan district, of which Boston is the centre. Prior to that time the service was supplied by independent horse car lines radiating from the business centre. There were no through lines, and few free transfers. In 1887 the Legislature authorized the consolidation of all but one of the street railway companies in Boston into the West End Street Railway Company. This consolidation marks the beginning of a serious study of the broad transportation problem of the city. It resulted in a comprehensive and coherent surface car service for Boston and its residential suburbs. Through lines were established connecting suburbs on opposite sides of the city, fares were reduced, the interchange of traffic between the various lines was facilitated, and in many other ways the public was provided with better accommodations.

The president of the company, Mr. Henry M. Whitney, immediately sought some motive power better for speed, power, and economy than horses. He had begun



The Boston Elevated Railway System

the installation of a cable system, when recent developments in the use of electricity were called to his attention, and with a fine foresight he so promptly appreci-

ated its possibilities that the cable project was abandoned, and electrical equipment substituted.

The first electric line, opened January 1, 1889, extended between Brookline and Boston, and was equipped in part with overhead trolley wire, and in part with an underground conduit system. The conduit portion proved unsatisfactory, and after several months' trial was abandoned, and later replaced with a trolley system. On the 16th of February, of the same year, the first complete trolley line, between Cambridge and Boston, was placed in operation, and gave satisfaction from the start. The first equipment was crude, but experiments on a large scale were made, costing, in the total, more than a million dollars; and in due time the experimental stage was passed, and the trolley system of operation became a demonstrated success.

With the installation of electrical equipment great improvements in the service were made, and large plans calculated to provide for future development were devised. Lines were extended into the suburbs, quicker time was made, larger and better cars were bought, fares were reduced, and free transfer privileges were considerably extended.

In 1897 the entire West End system was leased to the Boston Elevated Railway Company. During the same year the subway was opened for traffic and a new era began. Trunk lines of high speed and large capacity were planned to carry the bulk of the traffic above or below the public streets to points beyond congested and dense street traffic, there to be distributed by surface cars in the residential suburbs. The part to be played by the surface lines in the rapid transit system that is being worked out, is to carry passengers between outlying districts and the terminals of the trunk lines, and also to supply an accommodation service to and through the business district.

THE TREMONT STREET SUBWAY

Of the rapid transit structures, the first to be built was the Tremont Street subway. It was planned and

constructed under the direction of a public commission called the Boston Transit Commission, at a cost of about $4,000,000. It was authorized in 1894 and opened in 1897. It is owned by the city of Boston, leased to the West End Company, and subleased to the Boston Elevated Railway Company. It was not planned for high speed service, but was designed and used originally for surface cars exclusively. Its principal purpose was to relieve the business district of the city from excessive congestion by street cars, teams, and pedestrians. So many cars were being operated on Washington and Tremont Streets that they blocked each other, and rendered it impossible to provide an efficient service. Greater carrying capacity was imperative, and increasing the number of cars upon these streets was clearly impossible. It was therefore decided that the best way to meet this situation was to build an underground railway.

The engineers who designed the subway had no model to follow, but were obliged to depend entirely upon their ability to foresee the conditions and requirements of a new kind of service. The subway was equipped with three sets of tracks, — a through track and two loops. The through tracks, — now used for elevated trains, provide transportation across the business and shopping district; while the Park Street and Scollay Square loops enable cars from the west and north respectively, to reach this district at the subway stations for which they are named, where the cars pass around looped tracks and return.

THE ELEVATED RAILWAY PROJECT

The construction of both subway and elevated railway was authorized in the same legislative enactment in 1894. The two structures together provide the road-bed for the elevated trains. It may, therefore, surprise those unacquainted with the facts to learn that they were originally two separate and independent enterprises. At the time the legislation was passed, the public demand

was for an elevated road. The subway idea was not popular. The Legislature, however, combined the two schemes in one, and authorized both.

The old charter for the elevated road originally authorized the construction of an elevated railway of the Meigs type, but the project failed to attract financial support. It was believed that an elevated railway could not be made profitable, as it would be at a serious disadvantage in a competition with the excellent service given by the West End Company. Besides this, there was a lack of confidence in the novel and untried Meigs plan of operation, with its peculiar type of car running on a single rail. For these reasons the elevated charter lay dormant in the hands of the original incorporators.

In 1896 a number of local bankers and business men conceived a plan for giving Boston not only its desired elevated railway, but a better and larger service than had hitherto been attempted. The plan was to purchase the unused charter of the Meigs company; to secure amendments that would eliminate the doubtful Meigs system of operation; to obtain a lease of the West End system, and to unite the surface lines, the subway, and an elevated railway in one system. How all this was accomplished forms an interesting chapter in the history of local progress, but it is enough to say here that the plan was successfully carried out; and in 1897, the year the subway was opened, the Boston Elevated Railway Company assumed the operation of the local street railway system, and began to plan the details of its elevated road, which was opened for business on June 10, 1901.

The general plan of the elevated railway is easy of comprehension. The traffic is principally between a central business district and an outlying residential territory. The business district is bordered on the east by the harbor and on the west for a considerable distance by an open public park known as the Common. The principal highways and the lines of travel necessarily run north and south. The more important streets in and leading to the business section are crowded with a congestion of street traffic. With these things in view, the

elevated railway was therefore constructed between points north and south of the centre of traffic and beyond the congested territory.

The subway solved a serious difficulty by providing a possible, although unsatisfactory, road-bed upon which elevated trains could be run through a portion of the city where it would not be feasible to build an elevated structure on account of the large sums that would be required for the settlement of land damage claims. By utilizing the subway in connection with the elevated structure a high speed service is supplied that skirts the business area and extends both north and south to the suburban territory, in which the service is supplied by radiating surface lines connecting with the elevated railway at its terminals.

Briefly stated, the present functions of the elevated lines are to take the long distance north and south traffic out of the public streets and to carry it beyond the congested territory, and also to supply a fast service of large carrying capacity where the traffic is greater than can be accommodated by surface cars.

THE RAPID TRANSIT SYSTEM

As has already been stated, the territory in which the company supplies all of the street railway service is about 100 square miles in area and contains a population of upwards of 1,000,000. Besides the city of Boston, it includes the whole or portions of eleven other cities and towns. Cars from outside companies are operated upon lines connecting with the elevated train service at the terminals, and at the Park Street subway station by means of these cars passengers are able to reach places at a considerable distance from Boston without a change of car. From Park Square a line of high speed cars is operated to the city of Worcester, situated about 50 miles to the west. At the Sullivan Square terminal there are cars to be taken to the city of Lowell, 26 miles to the northwest. The system is laid out on the radial plan. A corresponding service east and west will be supplied

in the near future. A tunnel extending eastward, under a portion of Boston Harbor, connecting the business district with an important island called East Boston, is nearly completed. This line will probably be open for business during the present year. It is of interest to note that at the point where the tunnel passes underneath the elevated structure, the company will supply transportation at three different levels. A deep tunnel station is being completed at the junction of State Street and Atlantic Avenue. Above this station, upon the street surface, trolley cars are being operated. Over the street the elevated structure extends, and transfers may be obtained at this point between the different lines operating in all directions.

The rapid transit trunk line to the west will be built, in the relatively near future, from Scollay Square to or near Harvard Square in the city of Cambridge, the seat of Harvard University. This structure will consist of a subway at the Boston end and an elevated railway in Cambridge. It will cross the Charles River on a large and handsome bridge now in process of construction.

The Tremont Street subway has been found so poorly adapted to the requirements of an elevated train service that a new underground line is to be built under Washington Street for the accommodation of elevated trains. The present subway contains one eighth per cent down grade, and two up and two down grades of five per cent, besides numerous sharp curves. Station platforms are in some cases built on curves, and are too short to accommodate the increasing volume of travel. The Washington Street tunnel may be said to be fairly under way, as plans for a portion of the structure have been made, and some of the land takings effected. The tracks in this tunnel will be very nearly straight, the grades easy, and the stations designed so that platforms of sufficient length to accommodate eight car trains can be built. Upon the completion of the Washington Street tunnel the elevated trains will be removed from the Tremont Street subway, and the tracks now used by the elevated trains will be restored to their former use by the surface cars.

Another underground line has been authorized, crossing the business district in a north and south direction, to be built for the use of surface cars whenever it shall become necessary.

THE ELEVATED ROADWAY

The elevated roadway was designed and built under the direction of Mr. George A. Kimball, Chief Engineer. It was a little over two years in building, and was opened to traffic June 10, 1901. It cost approximately $400,000 per mile outside of stations and land damage expense. The distance between the terminals by way of Atlantic Avenue is 5.4 miles. The longest distance between stations is between Sullivan Square and Thompson Square in Charlestown, and measures 5,605 feet or 1.06 miles, while the shortest stretch of track between stations lies between State Street and Rowe's Wharf on the Atlantic Avenue line, and measures 988 feet or .189 miles. In the track layout there are 6.644 miles of main track, 6.468 miles of second track, and 2.903 miles of siding, switches, cross-overs, etc., making a total of 16.015 miles of track for elevated operation.

The minimum distance between the pavement and running rail is at Dudley Street, where it is 20 feet. The highest point is in Charlestown, at the junction of Main and Bunker Hill Streets, where the running rail is 39 feet 6 inches above the level of the street.

The tracks are laid 12 feet apart on centres. The running rail is standard A. S. C. E. section "T" rail, and weighs 85 pounds to the yard. The third rail is of the same pattern and weight and chemical composition as the running rail, except in the subway opposite stations, where a special rail is used. The guard rail is Pennsylvania Steel Company's, Section No. 116, weighing 100 lbs. to the yard. Guard timbers are bolted to the ties both inside and outside of the running rail. The inside guard timber is 4 inches and the outside one 10½ inches from the gauge of the running rail. The centre of the third rail is 19⅛ inches from the centre of the running rail. The

rails lie on Goldie tie plates, and are fastened by $5\frac{1}{2}$ in. × $\frac{9}{16}$ in. spikes of the Lehigh Valley R.R. pattern to ties of hard pine on the elevated structure and of chestnut in the subway, and are laid 16 inches on centres in the former, and 20 inches in the latter case.

ELEVATED STRUCTURE AND CONSTRUCTION

The elevated structure is built of medium steel, supported on steel posts resting on a foundation of concrete. In general, the foundations commence 10 or 12 feet below the surface of the ground, this depth being considered necessary for the requisite stability, and to provide against the danger of being undermined by the ordinary excavations made in the streets and sidewalks for sewers, conduits, foundations for buildings, or other excavations which are frequent in city streets. They are built of Portland cement concrete, laid in courses about two feet thick, the first course being of such dimensions as are necessary to distribute properly the load on the earth or piles, varying from 6 feet square in hard material to 12 or more in soft material. The courses are gradually diminished in size, the upper course being $4\frac{1}{2}$ feet square, on which is set a cast-iron pedestal; soft steel anchor rods 6 ft. 2 in. × $1\frac{3}{8}$ in. are embedded in the concrete and pass through the pedestal; and lugs on the steel posts where they are fastened by nuts, are afterwards embedded in concrete. Where piles are necessary, they are driven in such number and to such depth as to give a stable and safe foundation, and are cut off at a grade 5 feet above mean low water, or as much lower as necessary to get below the ground water level.

In the design, provision was made for the dead load of structure and track system, and for a live load of 50-ton cars, each 40 ft. long. The cars which are actually operated on this structure weigh about 30 tons empty, or about 36 tons crowded, and are 46 ft. $10\frac{1}{2}$ in. in length over all. In designing the structure, it was considered best to make provision for much heavier rolling stock

than is now used, as it is possible that future developments in methods of transportation may call for a locomotive system, or for cars that are much heavier than those now in use.

The stresses allowed in the concrete are as follows: Compressive, varying with the different grades of concrete from 300 lbs. to 450 lbs. per square inch. Tensile, not in excess of 30 lbs. per square inch. The maximum

Sullivan Square Terminal, B. E. Ry. Co.

tension in the anchor bolts is 16,000 lbs. per square inch. As the abutting power of the earth in resistance to horizontal forces has been neglected, the allowed tension in offsets for the bottom course and at the base of the anchor course, though in general not over 30 lbs. per square inch, has been as high as 35 lbs., and in a few instances 40 lbs.

The concrete was composed of American Portland cement, broken stone and sand, usually mixed in the pro-

portion of 1 part cement, 2½ parts sand, and 5 parts broken stone; but in practice the concrete for the lower courses was frequently mixed in the proportion of 1, 3, and 6, and for the upper course a richer mixture of 1, 1, and 3 was used. The difference in the mixture was made on account of the difference in pressure per square inch between the lower and upper courses. The number of foundations built in the streets was 1,133, and of these about one-half cost $260 each in round figures, or $9.50 per linear foot of double track structure. The remainder averaged about $700 each, or $25.50 per linear foot of double track structure, the increased cost being due to soft ground and interference with underground structures. These gross figures include the cost of pedestal castings, anchor castings and anchor bolts, all of which were furnished by the company, averaging $22.30 per foundation, also the cost of removing underground structures (paid directly to other corporations), averaging $18.30 per pier. The additional cost of concreting around the foot of each post and structure, and protecting it with wheel guards is not included in the figures.

On account of the crooked streets with varying widths, many different designs of structure are used. The upper section weighs 1,060 lbs. per lineal foot, the middle, 1,105 lbs., and the lower, 1,447 lbs. The floor system consists of cross-ties of Southern pine, 7 ins. by 8 ins. by 8 ft. long, laid 16 ins. on centres, and lapped 1 in. on the steel girder. Two inside 6 in. by 6 in., and two outside 6 in. by 9 in., hard Southern pine timbers are laid, parallel with the rail, as guards. The running rail, as already mentioned, is 85 lbs. T, American Society of Civil Engineers' standard. On curves of 400 ft. radius or less, a high 100 lbs. guard rail is used, which is bolted to the running rail, and further supported by the rail braces. The elevated stations are provided with island or intertrack platforms 160 ft. in length. The buildings and canopies over the platforms at the way-stations are built of steel covered with copper. The platform floors are of Southern hard pine timber, resting upon steel girders, and the stairways are of steel and cast iron.

ELEVATED RAILWAY OPERATION

Between the two terminals of the elevated lines, trains are operated in both directions by way of the subway. From each of the terminals a loop service is maintained in each direction through the subway and Atlantic Avenue lines. This arrangement enables passengers to reach any elevated or subway stations by means of the elevated trains.

The shortest headway between trains from the terminals is two minutes. Ten trains pass the signal towers every six minutes at the junction of the terminal lines with the Atlantic Avenue circuit during the period of shortest headway. During the rush hours thirty-four trains are in service on the elevated structure at the same time. The trains consist of three cars during hours of light riding, and four cars during "rush hours" when the patronage is highest, the rear car of each train being a smoking car. The average daily mileage is 20,000.

Free transfers, without the use of transfer checks, may be made between the elevated trains and connecting surface cars operating on tracks at the same level with the elevated trains at each terminal, and at the Park street and Boylston stations in the subway. At the Sullivan Square Terminal the surface cars connect with five suburban cities and towns; at Dudley street, with two, and at Park street and Boylston street, with seven. The population thus served amounts to approximately one million. The cars of other companies operating in districts lying beyond the Elevated's territory, and giving access to the whole of eastern New England, run to each of the terminals and to the Park street subway station. At each of the twenty-two stations free transfers are given between the elevated and surface lines.

An average of over 100,000 passengers are handled daily at each terminal, and about 60,000 each at the Boylston street and the Park street subway stations. During the evening rush hours, an average of 8,500 passengers per hour arrive at each terminal by train. Twenty-six thousand passengers have been admitted at an "island"

station in one day, the station being attended by two ticket sellers and two ticket choppers. The station stops average twelve seconds on the structure, and twenty in the subway. The paying passengers carried on the whole Boston system last year reached the enormous total of 233,563,578; and the car-miles footed up to 47,-688,487.

BLOCK SIGNALS

A feature of the elevated system is its very complete and successful equipment with positive block signals. In this it has followed and improved upon current steam railway practice, and this valuable innovation has resulted in remarkable operative success, and in a feeling of entire security on the part of the public that is most gratifying and unusual.

The block signals of the Boston Elevated Railway are electro-pneumatic; that is, the motive power is air controlled electrically.

The electric power and compressed air are furnished by small motor generator sets and compressors, located at suitable distribution points along the line. The current is supplied at 100 volts and the air at 85 lbs. pressure per square inch.

As in steam railroad practice, a "track circuit" is used, one rail of the track being given up to the signal system. This rail is divided into block sections by insulating joints. At one end of a block section, current is supplied to this rail, passing along the rail to the other end of the block, through the relay, which controls the signal movement, back to the other rail, returning along it to the other end of the block and the other pole of the current supply. If there is no train in the block, current thus supplied to the relay energizes it; the relay, in its turn, admits compressed air to the signal operating cylinder by means of a magnetic valve, and the signal is put to "clear" position. When a train enters the block, the relay is short circuited by the wheels and axles, being thus de-energized; the compressed air is shut off from

the signal and it goes to "Danger" by means of its counter-weight.

The system as a whole is unique in being the first track circuit system to be installed on an electric road, itself using the rails as a return path for the car-motor currents. As the tendency of this return current is, under certain conditions, to energize the relays, even with a train in the block, thus giving a clear signal, although the block might be occupied, special precautions had to be taken; the return copper for the car-motor current had to be sufficient to keep the return drop per signal block low; the relays had to be so adjusted as to respond only to a voltage higher than could ever be reached from the action of these return currents, and the track circuit voltage had to be kept high.

In steam railroad practice the usual track circuit voltage is that of one gravity cell — about one volt — while on this road, it is kept up to from fifteen to twenty volts. Although the electric power required is, from a steam railroad signal engineer's point of view, extreme, being 100 watts per block, as against the usual 0.1 watt per block used by steam railroads, this is of little importance, as electric power is so plentiful and readily available on electric roads.

Another thing to be guarded against in this installation, was the possibility of the car-motor current passing back through the signal rail and relay instead of through the other common grounded rail, which would be the case if the car wheels for any reason became insulated from this grounded rail, as might be the case in the presence of sand, snow, or sleet. To guard against this, the relay is made polarized, the field coils are energized from the track rails, as described above, while the armature coils are energized with a constant polarity direct from the signal supply mains. Under normal conditions the polarities of the field coils and armature coils are such that the armature swings to the right, closing the magnet valve circuit. If, however, owing to sand, snow, or sleet, the return current from the car motors fails to get its ground on the common return rail, and tries to find a

ground through the relay field coils, which are connected to the block rails, they become energized in the reverse direction, the armature is directed to the left instead of to the right, the circuit to the magnet valve remains open, and the signal stays at "Danger."

The automatic stop was first systematically applied in this installation. This automatic stop is a T-shaped

Automatic Stop for Air-brakes

piece of iron, which is mechanically connected to the signal, and rises alongside and above one of the running rails, when the signal is at "Danger." If a car goes by the signal under these conditions, the stop engages with the handle of a valve in the train pipe of the air brake

system and causes an emergency application of the brakes.

There are ninety-five track circuits on the road; most of these control the ordinary block signals, the remainder being used to safeguard interlocking signals. The shortest block is 297 feet long, and the longest 1,997 feet.

All the block signal equipment and the five interlocking towers are of the standard Westinghouse electro-pneumatic type. The system has proved highly efficient, the failures to operate from any cause whatsoever have averaged only about one failure for from twenty-five to thirty thousand movements, and a large proportion of these few failures have been from the grounding of the signal rail to the ironwork of the structure. There has never been a collision between trains in service, or of trains on the road — the whole road outside of the yards being protected by either block or interlocking signals.

CAR EQUIPMENT

To give the technical reader a clear idea of the exact material in rolling stock necessary for the successful handling of the great and rapidly increasing traffic of the elevated railway proper, the following schedule of equipment is appended. It is far greater in amount than was at first anticipated from the data available, and is steadily upon the increase.

174	passenger cars	Passenger car bodies built	
1	wrecking car	by Wason Mfg. Co.	53
1	construction car	St. Louis Car Co.	99
1	tool car	Osgood Bradley Car Co.	22
3	flat cars		
180	total number of cars.		

MEASUREMENTS OF PASSENGER CARS.

46′	10¾″	length over draw bars.
8′	9½″	width over drip boards.
8′	7¾″	width across platforms.
3′	8″	running rail to top of platform.
32′	2½″	between truck centres.
37′	6″	length inside car.
12′	5″	height of car.

5′ 6″	wheel base of trailer truck.
6′	wheel base of motor truck.
4′	width of middle door.
3½″	between platform and centre.

Weight of car light, 59,090 lbs. or 29.55 tons.
Weight of car loaded, 72,090 lbs. or 36. "
Percentage of weight on motor trucks, 63.45
Seating capacity, 48.
All cars carry fire extinguishers.

Motors: 200 Westinghouse 50-C, 150 H.P.
Gear ratio 50:21 = 2.38.
100 Westinghouse 50-E, 150 H.P.
Gear ratio 54:17 = 3.18.
48 Gen. Electric 68-E, 170 H. P.
Gear ratio 59:18 = 3.28.

Trucks: 104 Baldwin; Cradle motor suspension on 150 cars.
50 Brill; Swinging link nose suspension on 24 cars.
21 Curtis.

Wheels: Cast steel, cast iron and wrought iron centres. 34-inch steel tires on motor wheels, and 31-inch steel tires on trailer wheels. Use Krupp, Latrobe, Standard, and Midvale tires.

Each tire is ground about once every two weeks. About 48 pairs ground per day. This excessive wear is mostly caused by numerous curves on line.

Life of tires is from 2½ to 3 years.

Motor truck axle is 6½″, 7½″ in wheel and gear fit, 4½″ × 8″ at journal.

Trailer truck axle is 5½″, M. C. B., 3-3¼″ × 7″ at journal.

Air Brake: Christensen system. 2 compressors. Christensen motorman's valve.

24 new cars equipped with New York triple valves. All cars equipped with automatic trip and emergency valve.

Control: 150 cars equipped with Sprague Multiple Unit Automatic Control (cylindrical); 24 cars equipped with Sprague-General Electric Multiple Unit Automatic Control (contactor system).

Approximate maximum speed, 45 miles per hour.
Schedule speed averages 18 miles per hour.
Average k. w. hours per car mile, 4.0.

ELEVATED DIVISION

Repair Shops

The machine shop of repair shop is equipped with:

1 Putnam 90″ double head lathe.
1 Putnam 36″ tire truing lathe.
4 Springfield wheel grinders.
1 Putnam 300-ton wheel press.
1 Colburn key-way cutter.
1 Chicago Pneumatic Tool Co's 1½ ton pneumatic geared hoist.
1 15-ton electric travelling crane—40 ft. span (Cleveland).
1 6-ton hand travelling crane, with air hoist.
1 25-ton Otis plunger elevator.
1 Niles 60″ radial drill.
1 6-ton stationary air hoist.
1 20-inch shaper (Cincinnati)
1 18-inch lathe (La Blond).
1 Pond 42-inch wheel lathe.

All large tools are motor driven.

An Ingersoll-Sergeant motor compressor furnishes compressed air for forges, hoists, pneumatic hammers, and testing apparatus.

Rails and turntables are laid in machine shop floor for economical movement of trucks and wheels.

THE SELECTION AND TRAINING OF EMPLOYEES

The system of selecting men for employment in the car service is elaborate and efficient. The company is exacting in its requirements. Applicants whose general appearance is slovenly or unprepossessing are dismissed summarily, while those whose neatness, address, and apparent intelligence commend them are subjected to a preliminary examination and to various tests to determine whether or not they meet the requirements of the service.

These requirements are, in brief, that the applicant must be not less than twenty-one years nor more than thirty-five years of age for elevated service, nor more than forty-five years of age for surface-car service. His eyesight must be perfect. This is tested by the usual methods employed by oculists in fitting glasses, and the

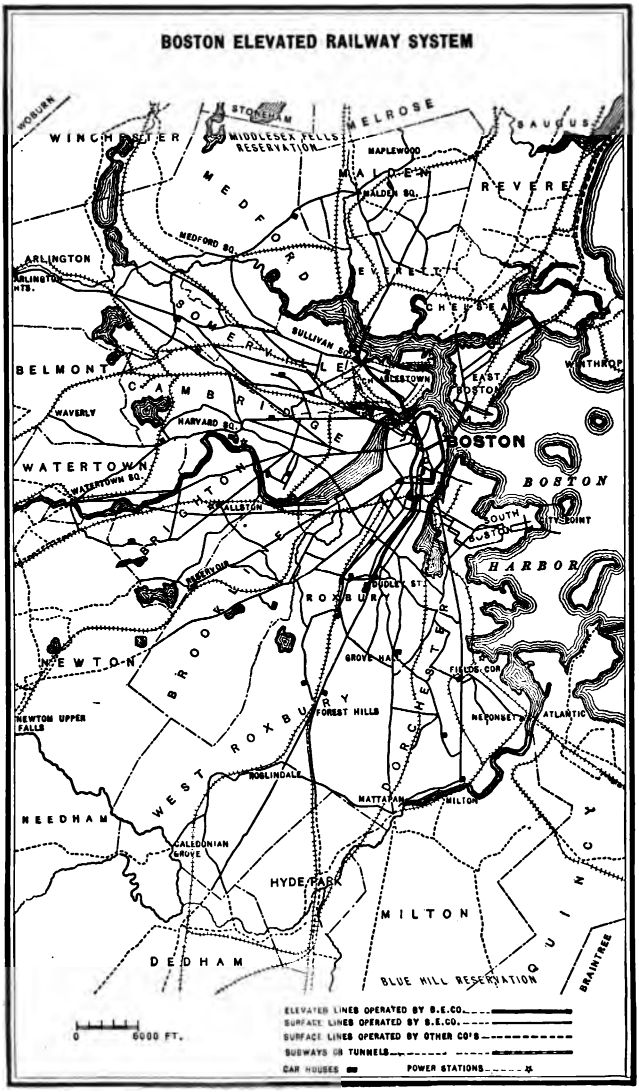
slightest defect in either eye is an absolute bar to further consideration. His hearing must likewise be perfect, and the applicant is required to nod his head in response to the clicks of a device that is sounded at varying distances and from different directions as a test for the quickness and accuracy of each ear.

Since the elevated lines were placed in operation an additional test for color-blindness has been added. The candidate is required to select from many skeins of worsted of various hues and shades those which he thinks match in general color certain samples that are handed to him. He is further required to name correctly the colored discs of light displayed by a lantern in a dark room, and a failure to select and name correctly is sufficient cause for rejection.

No man is employed as a conductor who is less than 5 ft. 4 in. in height, nor as a motorman or brakeman if he falls below 5 ft. 6 in.; and no man can enter the car service at all unless his fingers and thumbs are all present and in good working order. Conductors must possess a common school education, and motormen must be able to read and write the English language.

If this preliminary examination discloses no unfitness, the applicant's moral character is investigated with the greatest possible thoroughness. If this investigation establishes positively that the candidate is trustworthy and otherwise desirable, he is sent to the company's physician for final physical examination. This examination is intended to disclose any constitutional or organic defects that might interfere with the discharge of his duties in a long term of employment. About one out of every eight is rejected by the physician. The kidneys, heart, lungs, and feet have been found to be particularly vulnerable points in men employed upon the cars; and the company feels that it is not justified in the expenditure of the time and money necessary to break in new men who are not absolutely sound in these respects.

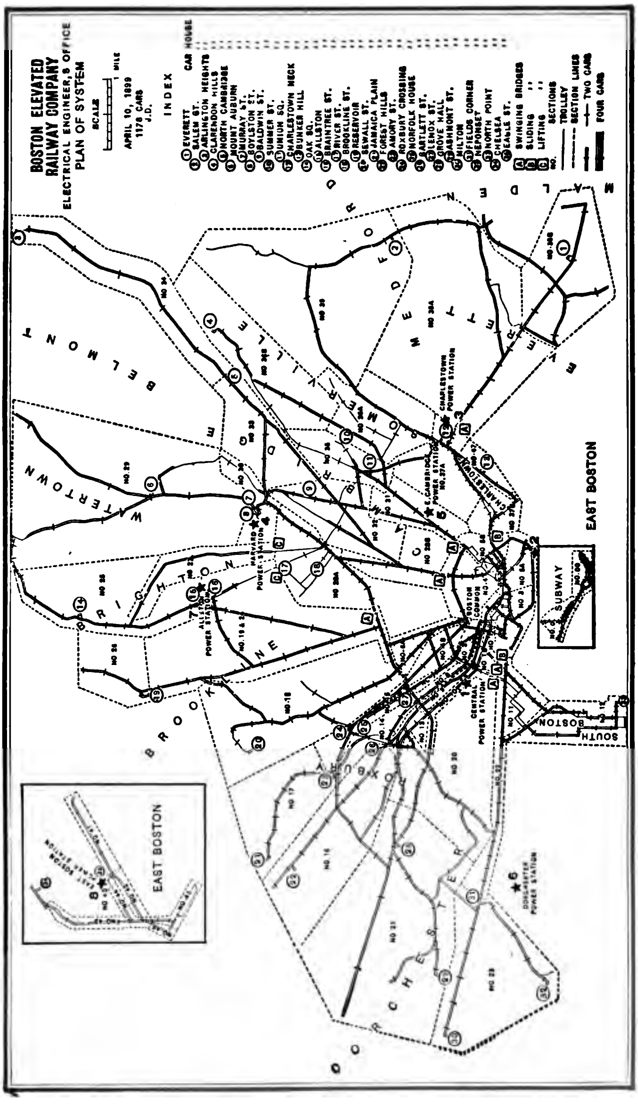
The number of men who succeed in running the gauntlet of all of these examinations amounts to only about twenty-five per cent of the total who apply for


BOSTON ELEVATED RAILWAY SYSTEM
WOBURN
WINCHESTER
STONEHAM
MELROSE
SAUGUS
MIDDLESEX FELLS RESERVATION
MAPLEWOOD
MALDEN
MALDEN SQ.
REVERE
MEDFORD
MEDFORD SQ.
ARLINGTON
ARLINGTON HTS.
EVERETT
CHELSEA
SOMERVILLE
SULLIVAN SQ.
BELMONT
CHARLESTOWN
EAST BOSTON
WINTHROP
CAMBRIDGE
WAVERLY
HARVARD SQ.
BOSTON
WATERTOWN
WATERTOWN SQ.
BRIGHTON
ALLSTON
BOSTON HARBOR
SOUTH BOSTON
CITY POINT
RESERVOIR
BROOKLINE
DUDLEY ST.
ROXBURY
NEWTON
GROVE HALL
DORCHESTER
FIELDS COR.
NEWTON UPPER FALLS
FOREST HILLS
NEPONSET
ATLANTIC
WEST ROXBURY
ROSLINDALE
MATTAPAN
MILTON
NEEDHAM
QUINCY
CALEDONIAN GROVE
HYDE PARK
MILTON
DEDHAM
BRAINTREE
BLUE HILL RESERVATION
0 6000 FT.
ELEVATED LINES OPERATED BY B.E.CO.
SURFACE LINES OPERATED BY B.E.CO.
SURFACE LINES OPERATED BY OTHER CO'S
SUBWAYS OR TUNNELS
CAR HOUSES
POWER STATIONS

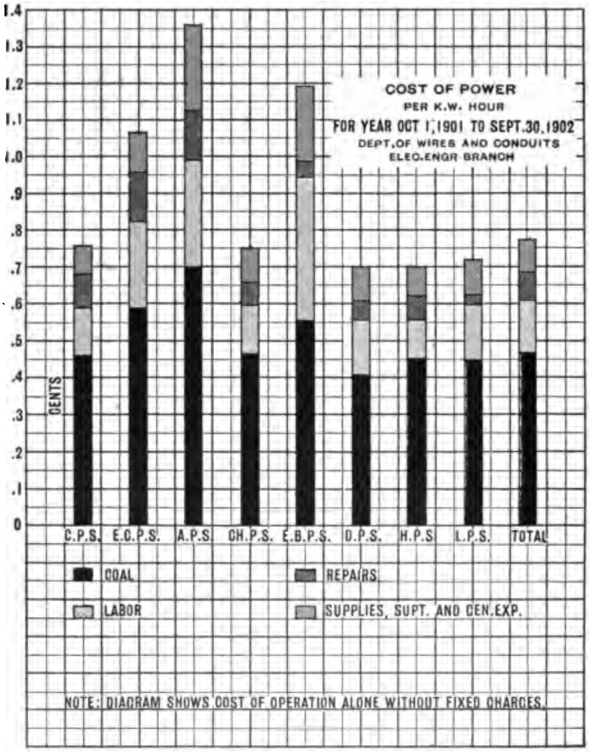
positions. It is doubtful if any other corporation or concern, public or private, exercises so great care in the selection of men for service. As a further precaution the company requires every conductor to furnish a bond with two real estate owners as sureties, each in the sum of three hundred dollars. The bonds of surety companies are not accepted, for the reason that it is believed that the stipulation of private bondsmen is certain to result in securing greater fidelity among the employees. An individual will not assume the risk of losing three hundred dollars by the misconduct of another unless he has very excellent grounds for believing in the honesty of the person for whose possible wrong-doing he is to be held liable.

An applicant who has passed the various tests, and convinced the employment department that he is in all probability capable of becoming a satisfactory operative, is then placed under instruction. On the surface lines the men are taught on the cars by instructors selected from the more competent motormen and conductors. The instructions include the rules, training in the performance of ordinary duties, equipment and mechanism of street cars, and the proper treatment of accidents and emergencies.

The course of instruction for elevated employees is similar in general principles to that for surface employees, but the method of instruction is different and of more popular interest. Men assigned to the elevated divisions begin as brakemen, are in time promoted to be guards, and finally become motormen. For each of these positions instruction and the passing of a rigid examination is required. For the purpose of teaching and demonstration, a school-room has been equipped in the Sullivan Square terminal station. In this room there has been built a skeleton three-car train containing all of the mechanism of a regular train, except the trucks. There are no sides, seats or roofs to the cars, these having been omitted in order that the mechanism may be exposed to view and accessible for examination. Upon this train new men and candidates for promotion are shown the


BOSTON ELEVATED
RAILWAY COMPANY
ELECTRICAL ENGINEER,S OFFICE
PLAN OF SYSTEM
SCALE
1 MILE
APRIL 10, 1899
1178 CARS
J.D.
INDEX
CAR HOUSE
EVERETT
SALEM ST.
ARLINGTON HEIGHTS
CLARENDON HILLS
NORTH CAMBRIDGE
MOUNT AUBURN
MURRAY ST.
BOYLSTON ST.
BALDWIN ST.
SUMMER ST.
UNION SQ.
CHARLESTOWN NECK
BUNKER HILL
OAK SQ.
ALLSTON
BRAINTREE ST.
RIVER ST.
BROOKLINE ST.
RESERVOIR
SEWALL ST.
JAMAICA PLAIN
FOREST HILLS
AMORY ST.
ROXBURY CROSSING
NORFOLK HOUSE
BARTLETT ST.
LENOX ST.
GROVE HALL
ASHMONT ST.
MILTON
FIELDS CORNER
NEPONSET
NORTH POINT
CHELSEA
EAGLE ST.
SWINGING BRIDGES
SLIDING
LIFTING
SECTIONS
TROLLEY
SECTION LINES
TWO CARS
FOUR CARS
EAST BOSTON
SOUTH BOSTON
SUBWAY

location, operation, and use of the various devices. They learn how to connect a train, how to put it in order to take out of the yard, how to operate it, how to give and respond to the various signals, what to do in emergen-



Cost of Power in Plants of Boston Elevated Railway Company

cies, and how to lay up a train when it is hauled off the main line. There is no make-believe about anything except the motion of the train. No man is permitted to assume the responsibilities of his position until he has demonstrated on the dummy train that he is thoroughly

familiar with his duties and with the equipment he is expected to handle. An absolutely perfect examination must be passed before the train-master will certify that a candidate is qualified for the service. The examinations for brakemen, guards, and motormen are different, and consist of prescribed questions that are answered orally or by demonstration.

GENERAL RELATIONS WITH EMPLOYEES

The company does its utmost to thoroughly instruct new men, and it is equally painstaking in their subsequent training. It aims to perfect every man as fully as possible in all the details of the business, not only because it must have reliable men on the cars, but because it must find its future superintendents, inspectors, and other officers among the men who to-day manipulate the controller and bell chord.

Every man brings a new problem to his superintendent and assistants. It is their duty to see that all accepted men are made into good men, to see that good men are made better, and to see that the best men are recommended for promotion.

With this end in view, leniency and consideration are extended to new men who are at fault until the company is satisfied that they are well versed in the rules which should govern their conduct, but men who negligently and willfully violate rules are disciplined by reprimand, suspension, or discharge. Suspension is a severe form of discipline, imposed only for serious offences. Repetition of these offences leads to discharge.

The work of every man is studied by his superiors from the day he begins to run a car until his connection with the company is severed. It is no slight task to keep a watchful eye upon the conduct of five thousand men who are performing their duties far from those who are held responsible for what they do, say, or omit; but, with the aid of a force of uniformed and non-uniformed inspectors, it is possible to keep up a very good supervision of the work of each man.

Although a division superintendent cannot be so intimately acquainted with every man under his authority as to know, as a matter of memory, the temperament, merit, and capability of each, yet as a matter of justice to the company and to the employees, some form of record must be provided ; and for this reason, among others, a ledger account is kept with every man that makes full information available whenever an employee is under consideration for discipline or reward.

Each surface division is sub-divided into districts, and a street inspector in uniform is assigned to duty in each district, and is held responsible, so far as possible, for the movement of cars, correction of mistakes, violations of rules, and for report of defects that occur within the district. This is accomplished by informing any motorman or conductor of any failure of conduct observed by the inspector, and explaining the nature of the error and how it should have been avoided, later making a full report of the occurrence to the division superintendent. Inspectors, from time to time, are assigned to different districts, so that all may have a thorough knowledge of the entire division. Street inspectors are not only expected to observe and report upon everything affecting the service, but are to keep traffic moving by diverting cars in case of accident, fire, or other obstruction. They are required to regularly report by telephone to the office of the division superintendent.

As a result of the efforts of the street inspection force, both the number and proportion of accidents attributable to motormen and conductors have been greatly reduced. The plan is to have every mistake or wrongful act pointed out and explained at the time it occurs, while every circumstance is in the mind of the offender. Uniformed inspectors explain, instruct, correct and report, but all matters of discipline are decided by the division superintendents and their superior officers.

Another corps of inspectors, who wear no uniforms, supplements the work of the division inspectors. These men are selected and trained with the greatest possible care to observe and report upon the conduct of the men

as it appears from inside the cars, in the same manner that the street inspectors observe from without. The reports of these inspectors are of the greatest possible value to the management and to the men who perform their work well.

In dealing with the men collectively every effort is made to bring about an atmosphere of sympathetic and harmonious co-operation. One of the most successful methods employed for this purpose is the holding of meetings of a semi-formal nature for the discussion of operating problems. Twice each month the Superintendent of Transportation holds meetings of superintendents of divisions and departments. These meetings are opened with a talk by the Superintendent of Transportation upon some subject relating to division management, the improvement of the service, the interpretation of rules, and other kindred themes. After his address an "experience meeting" is held, in which all participate. At first the discussion usually centres upon the subject presented by the Superintendent of Transportation, but after that is disposed of, all sorts of subjects are brought up. Reports are made, advice is asked and given, and ideas are exchanged.

Once a month a similar meeting of chief inspectors, and such other inspectors as choose to attend, is conducted by the Superintendent of Transportation, and the same general programme is followed. Division superintendents also conduct meetings of inspectors and starters attached to their divisions, and explain and discuss the affairs of the division. They also hold meetings of the car men at such times and places as will enable every man in the division to attend at least one meeting each month. In this manner the management, through its direct representatives, talks as often as once a month to every man directly engaged in handling traffic.

The company strives to show its interest in the welfare of the men in many ways, and does all that is possible for their well-being. Among other things it pays about the highest wages in the country. Conductors and motormen on the surface lines receive $2.25 per day for

10 hours' work, and 4 cents for every ten minutes overtime, while 35 and 40 cents per hour is paid for snowplow work.

On the elevated lines all men are paid by the hour. Ten hours constitutes a day's work, and on that basis brakemen who are beginners are paid $1.85; guards are paid $2.10, and motormen $2.30 the first year, $2.40 the second year, and $2.50 for subsequent service. Learners are paid $1 a day; extra men are guaranteed about two-thirds full pay for being on call, whether work is given them or not, and are paid more if they earn more. All men in the car service are paid 5 cents a day extra for five years' continuous service, 10 cents for ten years, and 15 cents for fifteen or more years. Fifteen dollars extra pay is given at the end of each year for meritorious service.

Men who have spent twenty-five years in continuous service, or have reached the age of sixty, after fifteen years of continuous service, upon becoming incapacitated for future work are granted an annuity, usually $25 a month, for the remainder of their lives. The company never discharges a man except for cause, and endeavors to make the lot of its employees as comfortable as possible, often going far out of its way to do so. During the recent coal strike the company imported twenty thousand tons of coal to be distributed among its employees at cost; and many a house was warmed that would otherwise have been cold and wretched.

The lobbies at the car sheds are made thoroughly comfortable for the men. They are supplied with papers, magazines, and other good reading matter at an annual expense of more than $1,500. The toilet and sanitary arrangements are adequate and convenient. The car-sheds are business establishments, and not club houses; nevertheless the company endeavors to provide wholesome, attractive, and comfortable quarters for its employees.

The company pays the running expenses of two mutual benefit associations organized and conducted by employees. Both of these associations pay members

$7 a week during sickness not exceeding ten weeks in a year, and one of them pays $100 and the other $1,000 in case of death. All of the payments for sickness and death are met by monthly assessments. The annual cost of membership is about $15. The company assumes the cost of collecting and distributing the money, of keeping the books and other incidental expenses, so that every dollar contributed by the men is available for distribution. The contribution of the company for this purpose amounts to nearly $7,000 annually. A very good band of music has been organized among the men, and this is also supported by the company.

Then, too, the company comes to the relief of men in individual cases of hardship. Efforts are constantly being made to make the men feel that the management is a friend and helper to every man who is loyal to the service, and faithful in the performance of his duties. The legal department may be consulted by any employee free of expense. The President is accessible to every individual at all seasonable hours, and no person having legitimate business to present is ever denied an audience. The President is always ready and glad to discuss any matter with individuals or groups, and make changes or adopt suggestions whenever it is feasible to do so.

Perhaps what has already been said will give a general idea of the manner in which the company deals with the individual. At best it can be no more than suggestive of the many other means adopted to establish an individual relationship between every employee and the central office. The aim is to have every man feel that the management has a personal interest in him, that it is anxious to help him improve, that if he does well it is known and he receives credit, and that if he does ill it is also known and he must take the consequences.

POWER STATIONS AND ELECTRIC SYSTEM

The Boston Elevated Railway system comprises 421.5 miles of tramway tracks, and 16 miles of elevated tracks, all within a radius of seven miles from the State House on Beacon Hill.

For the operation of these tracks there are required about 1,550 closed tramway cars and a like number of open cars, and 174 elevated cars.

The elevated road traverses the heart of the city from north to south, connecting with the surface lines in terminals at either end and at every intermediate station. In the city proper there are two branches, one through the subway, underground, and the other by the water front overhead.

Collector and Track Brush

Power for this work is furnished by eight power stations, operating on the 550 volt, direct current, track return, system.

These power stations, with a total normal generating capacity of 36,444 kilowatts, are divided, as to size and number of units, as follows:

1. CENTRAL POWER STATION		
Capacity, 14,400 k.w.	Units	1–2700 k.w. 2–1500 " 6–1200 " 30–50 "
2. LINCOLN POWER STATION		
Capacity, 8,100 k.w.	Units	3–2700 k.w.
3. CHARLESTOWN POWER STATION		
Capacity, 4,300 k.w.	Units	1–2700 k.w. 2–800 "

4. Harvard Power Station
Capacity, 3,600 k.w. Units 3–1200 k.w.

5. East Cambridge Power Station
Capacity, 2,700 k.w. Units 6–450 k.w.

6. Dorchester Power Station
Capacity, 2,000 k.w. Units 2–1000 k.w.

7. Allston Power Station
Capacity, 744 k.w. Units 12–62 k.w.

8. East Boston Power Station
Capacity, 600 k.w. Units 3–200 k.w.

Reference to the map on page 57 will show the location of the several power stations, each one being represented by a star. All are located on tide water with the exception of the Allston power station, so that water is available for condensing purposes.

1. Central Power Station

This, the main station of the system, is situated on Harrison Ave., south of Dover Street.

The equipment consists of six 1,800 h.p. horizontal triple-expansion, condensing engines; two 2,000 h.p. horizontal, cross-compound, condensing engines; and one 4,200 h.p. vertical cross-compound condensing engine, all direct coupled to multipolar generators.

Condensing water is drawn from the South Basin, nearby, and is utilized in condensers of the Bulkley siphon type.

The boiler room is in tandem with the engine room, and the boilers are arranged in two rows facing each other, with a track down the center from which coal cars discharge their load in front of each unit. The boilers are hand fired.

Coal is brought by electric locomotives and cars from the coal wharf across the street, where two electrically operated buckets on travelling cranes discharge the coal from lighters and barges, over tunnels equipped with

chutes for loading cars for transportation to this and other power stations and car houses. The wharf has a storage capacity of about 24,000 tons of coal.

Lincoln Power Station

In a building adjacent to the main station are 30–50 k.w. bipolar generators, belted to tandem compound, high speed, engines. These machines were originally installed for temporary use in an old building on the premises, to

be used during the construction of the main power house. This plant has never been discarded, although but little used.

2. Lincoln Power Station

This is the newest station of the Company, and is situated on the harbor front at the corner of Atlantic Avenue and Battery Street.

The equipment consists of three 4,200 h.p. vertical, cross-compound condensing engines, direct coupled to multipolar generators. The boiler room is back of and parallel with the engine room. The boilers are arranged in two rows, facing each other, and are fed with coal from the bunkers overhead, through hoppers to mechanical stokers.

The condensers of this station are of the jet type, the pumps for the same being steam driven. Condensing water is taken directly from and discharged into the dock.

A coal handling and storage plant is situated on the wharf directly back of the power station, equipped with 3 steam-operated coal towers, and having a storage capacity of about 4,000 tons of coal. The coal is transferred to the bunkers over the boilers by a system of moving buckets.

An unusual feature of the electrical equipment of this station is the generator switchboard, on which there are only the positive terminals and connections of the generators, the negative terminals being connected directly to the negative bus.

3. Charlestown Power Station

This station is situated near the northerly terminal of the elevated road in Charlestown. Its equipment consists of one 4,200 h.p. vertical, cross-compound, condensing engine, and two 1,000 h.p. horizontal, cross-compound condensing engines, all direct coupled to multipolar generators.

The condenser for the large engine is of the Bulkley siphon type with steam circulating pump. The conden-

sers for the two small engines are of the jet type with steam pumps.

The boiler room is back of and parallel with the engine room, and the boilers are arranged in a single row. Coal is conveyed by a bucket conveyor to the bunkers above the boilers, to which it is fed by mechanical stokers.

4. Harvard Power Station

This station, as its name implies, is situated not far from Harvard Square, on Boylston Street in Cambridge.

Its equipment consists of three 1,800 h.p. cross-compound, horizontal, condensing engines, direct coupled to multipolar generators. The condensing water is drawn from the Charles River on the shore of which the station is located, and is utilized in jet condensers, equipped with steam air and circulating pumps.

The boiler room is back of and parallel with the engine room, and the boilers are arranged in one row. Coal is brought to this station from the coal wharves at Central or Lincoln Power Stations by a specially designed car, and is deposited, through openings in the bottom of the car, into coal bunkers below the track, from which it is conveyed by small cars and an endless chain, and deposited in hoppers above the furnaces, from which it is discharged into mechanical stokers.

5. East Cambridge Power Station

This is one of the oldest power stations and is situated in East Cambridge on the river front. The equipment consists of two 1,000 h.p. and one 500 h.p. horizontal triple-expansion, condensing engines, with broad face flywheels, belted to a jack shaft, from which are belted six 4-pole generators. This jack shaft is divided into three parts, which may be united by means of clutches.

The condensers for two of the engines are of the surface type, and for the other one of the Bulkley type, with steam pumps. The boiler room stands at right angles with the engine room, and the boilers are arranged in one

row. Coal is discharged at the station from lighters and deposited in a pile in front of the boiler house, into which it is wheeled by hand. The boilers are hand fired.

6. Dorchester Power Station

This station is located on the shore of Dorchester Bay on Commercial Point. Its equipment consists of two 1,500 h.p. horizontal, cross-compound condensing engines, direct coupled to multipolar generators. The condensers are of the jet type with steam pumps.

The boiler room is back of and parallel with the engine room, and the boilers are arranged in one row. Coal is discharged from lighters at the wharf alongside the power station, and is deposited in a pile near the building, from which it is wheeled into the boiler room and shovelled into hoppers, through which it passes to the mechanical stokers with which the boilers are equipped.

7. Allston Power Station

This is the oldest of all the stations. It was built to operate the first electric cars run in Boston, and was originally designed for one-half the present size, but the design was changed and the station doubled in capacity before it was finished. Its equipment consists of four horizontal-tandem, compound, high speed non-condensing engines, belted to bipolar generators. The boiler room is back of and parallel with the engine room and the boilers are arranged in one row. They are of the fire tube type and are hand fired.

Coal is brought to this station from the coal wharf at Central or Lincoln Power Stations by means of a specially designed coal car, and the coal is deposited on the floor of the boiler room in front of the boilers.

8. East Boston Power Station

This station is located in East Boston on the water front and supplies power for that part of the system located on the island. The equipment consists of three

250 h.p. horizontal, cross-compound, condensing engines, direct coupled to multipolar generators. The condensers at this station are of the jet type with steam pumps. The boiler room is back of and parallel to the engine room, and the equipment consists of three internally fired, vertical tubular boilers which are hand fired. Coal is brought to this station by teams from the coal wharf at Lincoln Power Station, and is deposited on the floor of the boiler room.

These eight power stations, although separated from one another by distances ranging from 2 to 3 miles, operate in parallel with each other through feeder sections to which two or more of them are connected.

DISTRIBUTION OF POWER

The whole system is divided into 65 feeder sections, controlled by switches and circuit-breakers at the several power stations; 21 of these are sections which are fed from two or more stations, and it is through the copper connecting these sections with the power stations that the latter are worked in parallel.

The morning load works from the outer part of the system radially toward the centre, and the evening load, in the reverse manner. This tie copper together with the adjustment of station voltage, permits of a fairly uniform load and a high load-factor for each station.

If one of the generating units at one of the power stations becomes disabled, the load upon that station is reduced by lowering its voltage, allowing the other stations to assume the extra burden to an extent proportional to their several abilities.

Service has been maintained in this manner at a time when two of the 2,700 k.w., and one of the 1,300 k.w. units were out of service at times of maximum load.

TRANSMISSION SYSTEM

The feeders and returns are carried underground from all stations, except East Cambridge, Allston, and East Boston, from which they are still carried overhead.

The standard sizes of wire for overhead feeders are 500,000 c.m. and 1,000,000 c.m. The standards for underground work are 500,000 c.m., 1,000,000 c.m., and 2,000,000 c.m., the latter size being used for carrying the heavy currents required in the elevated service. The standard size for trolley wire is No. 00.

In underground work vitrified earthware duct is now the standard construction. There are, however, some few miles of cement-lined iron pipe, installed at the inception of the work of placing feeders underground.

There are emergency connections between adjacent surface feeder sections and between adjacent elevated feeder sections; and there are also emergency connections between the elevated and surface sections, so that, in the event of failure of the copper of any section, service may be quickly restored. Seven emergency crews with properly equipped wagons are located at advantageous points over the system, ready to respond to orders from the power station authorities in time of trouble.

The elevated lines are operated by the third rail system, current being collected for the motors of the cars by a special form of spring collecting shoe.

Throughout the subway this third rail is divided into sections corresponding in length with the signal blocks, and controlled by a conveniently located switch, so that, should an accident occur to the electrical equipment of a train while in the subway, it may be isolated very quickly.

The following facts concerning the transmission lines and feeder sections may be of interest. The longest distance over which power is normally transmitted from each power station is as follows:

From	Central,	8.05	miles (with boosters).
"	Lincoln,	2.10	"
"	Charlestown,	5.17	"
"	Harvard,	5.91	"
"	East Cambridge,	6.13	"
"	Dorchester,	5.00	"
"	East Boston,	1.98	"

The average distances over which power is normally transmitted from each station, to the electrical centres of gravity of the feeder sections, are as follows:

Central,	1.40 miles
Lincoln,	1.14 "
Charlestown,	2.75 "
Harvard,	2.14 "
East Cambridge,	1.50 "
Dorchester,	1.28 "

Miles of trolley wire,	413
" " feeder and return wire (overhead) (in 500,000 c.m. equivalent),	551
" " " and return wire (underground) (in 500,000 c.m. equivalent),	295
" " submarine cable,	4.6
" " underground conduit structure,	26.5
" " " " duct,	239.5
Number of manholes,	583

No. of feed taps to trolley (direct),	633
" " " " " " (through switches),	800
" " connections to tracks from return wires,	608
" " insulating joints in trolley,	913
" " poles (all kinds),	18,102

The most striking electrical feature of the Boston Elevated Railway system is the fact that the company has adhered consistently to the policy of generating its power at a number of independent stations, instead of following the now common fashion of generating at one colossal plant and transmitting power at high tension to sub-stations with rotaries feeding various parts of the network. This diversity in practice is not without reason. It does not represent either extreme conservatism or a condition of being hopelessly behind the times, but rather a realization of the possibilities of economical generation of power in stations of moderate size.

One of the points most often argued among electrical engineers, is the variation of power-cost with capacity of station, other conditions remaining approximately equal. Representing this variation in the form of a curve, it is clear enough that at some point of output this curve be-

comes asymptotic; that is, at some capacity of indeterminate amount a further increase in size does not effecta perceptible saving in cost. The present tendency has been to assume, in many cases without adequate proof, that this critical size is extremely large, so that stations of 50,000 to 100,000 kilowatts output have been frequently planned, and sometimes in fact built. Obviously in order that generation of power at such a colossal station shall prove finally to be economical, it is necessary that the cost at this station be small enough to permit material losses in transmission and in the rotaries at the sub-stations, still leaving the net cost of power at the sub-station bus-bars less than it would be if generated in separate stations at approximately the same points.

There is good reason to believe that the aggregate of these losses, including proper charges for the maintenance and depreciation of the transmission lines, is large; seldom, perhaps never, less than 25 per cent of the total cost of power; sometimes, perhaps rather often, in excess of that amount.

The concrete problem which faces the engineer is therefore the possibility of saving, by generating in one immense station, enough in cost of power to enable him to lose with impunity what may be a very material fraction of the whole. Can he, in other words, by building one station of 50,000 kilowatts capacity, or more, produce and distribute (costs being reckoned at the sub-station bus-bars) his power more cheaply than if those bus-bars were fed by separate stations? Under existing conditions here in Boston, the engineers of the Boston Elevated Railway Company have steadily held to the negative of this proposition, believing that where it is possible, as it is here, to locate independent stations practically upon tide-water, or at least at points extremely accessible, the costs of generation in stations of moderate size are so near those which can be attained under similar conditions in very large stations as to leave no margin for the necessary losses of transmission and of sub-station operation.

The annexed diagram shows in a most vivid and con-

vincing manner the substance of their argument from practice. This diagram gives the cost of power per kilowatt hour for a complete year for each of the generating stations of the system, and the average of the whole. It must be distinctly understood that these costs are not computed costs or values determined from sets of experimental runs of the various plants. They are the figures of operation day in and day out, as obtained at each of the plants. Each station is, in fact, under continuous test, the amount of coal used and the amount of water evaporated being determined as part of the regular operation of the system. The final costs, therefore, represent what actually happened.

The diagram shows the complete and final costs of operation without the fixed charges annexed, which is the common and customary method of comparison in considering power-house costs. A glance at it shows at once that three of the stations, those at East Cambridge, Allston, and East Boston, are conspicuously higher in cost of power production than any of the others. The latter two of these are small stations: Allston of 744 kilowatts, in small units; East Boston of only 600 kilowatts, in three units. The East Cambridge power station, although of an aggregate capacity of 2,700 kilowatts, is composed of units of only 450 kilowatts each. The other five stations all show low costs of power. At Dorchester and at Harvard the cost per kilowatt hour is just seven-tenths of a cent. At the Lincoln power station it is 0.725 cent; at the Charlestown power station 0.755 cent; at the Central power station 0.76 cent; and in the total, taking into consideration the adverse effect of the three old and relatively inefficient stations, the final cost is only 0.775 cent.

The three typical modern power stations, Dorchester, Harvard, and Lincoln, show operating costs of a most gratifying character, and the point which deserves especial notice is that the Dorchester and Harvard stations, the former of 2,000 and the latter of 3,600 kilowatts, are perceptibly better in performance than the Central power station of over 14,000 kilowatts, and the Lincoln power

station of over 8,000. A cost of power of seven-tenths of a cent per kilowatt hour, with coal at $3.60 per ton, which was the actual average during the period covered by the diagram, is so low as to leave no reasonable margin for the losses in, and cost of, high voltage transmission and sub-station work, deriving its energy from a central power station. Unquestionably, part of the excellence of the result reached is due to the fact that the stations are skillfully handled, not only as units, but as a whole, so that the load factors are kept high as far as it is possible to keep them high upon a street railway system. Another most interesting point is that the Central station, with hand fired boilers, shows a lower cost for coal and labor combined than either the Lincoln or Charlestown stations with mechanical stokers. Whatever the explanation may be, the uncompromising fact is in evidence.

So far as conditions existing here in Boston are concerned, this diagram is a complete vindication of the wisdom of the policy which has been pursued. There is very small probability that, using any present prime movers and electrical apparatus, a station of any practicable size located on tide-water in or near Boston, could actually turn out power cheaply enough to permit economical transmission over the Boston network as against stations showing the performance of the best of these individual stations, or even of the average.

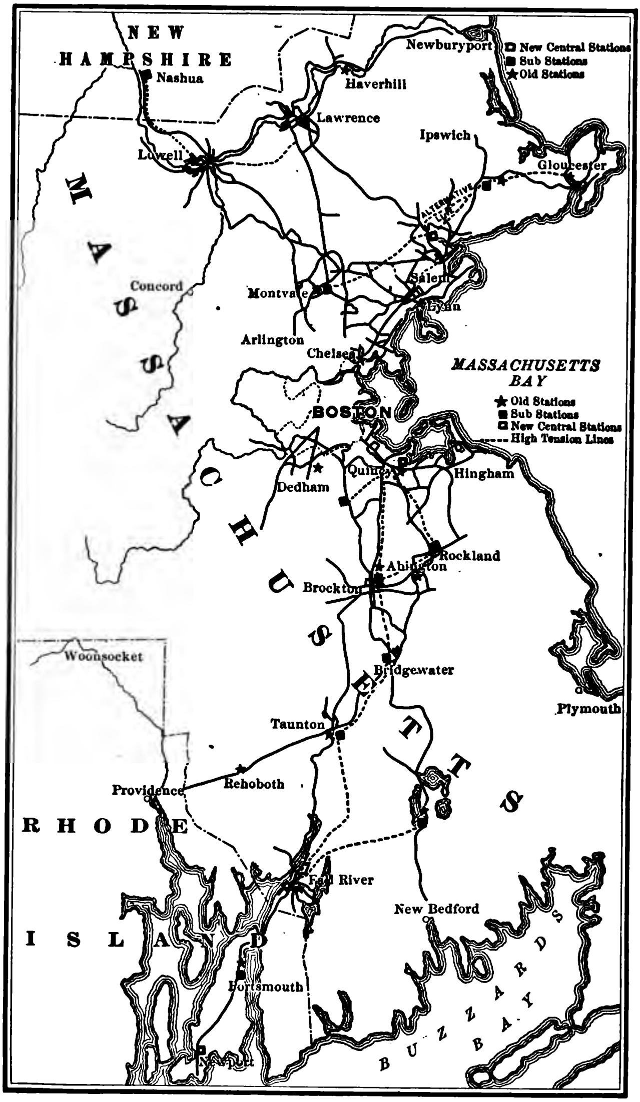
There may be opportunities in this territory for the economical transmission of power to sub-stations (the conditions which exist in the Boston network do not necessarily exist in other localities); but taking things as they are, the simplicity of the method and the excellence of the results are a striking lesson in the intelligent installation and management of medium sized stations, a lesson which engineers in other parts of the country would do well to take to heart, at least to the extent of investigating carefully the conditions of power generation on a moderate scale in connection with the transmission of power to sub-stations. There is no final and definite solution to a problem such as this; all solutions

are necessarily special and proximate; but the results attained in the practice of the Boston Elevated Railway Company are certainly worthy the solemn consideration of those contemplating the construction of enormous generating stations.

The Massachusetts Electric Companies

ASIDE from the work of the Boston Elevated Railway Company, the suburban lines in the vicinity of Boston are in the hands of several organizations, the Newton & Boston Street Railway, the Boston & Worcester Street Railway, and other corporations; but the great mass of the work, north and south of the city, has fallen to the lot of the Massachusetts Electric Companies. This organization is a voluntary association of owners of stock in two previously existing large street railway systems and in one electric light company.

The larger organization was formed in 1899, and is managed by a board of trustees, who hold the title to all its assets. Practically, it has complete control of the Hyde Park Electric Light Company and of the Boston & Northern and the Old Colony Street Railway Companies. These last two had previously come into existence through the virtual consolidation of a very large number of interests. Thirty-two street railway companies have thus come under the control of one carefully managed and coherent organization, doing an immense business north and south of Boston, including most of the street railway facilities of Massachusetts, and lines as far north as Nashua, N. H., and extending on the south as far as Fall River, Newport, and Providence, R. I., and connecting at the Boston end with the Boston Elevated system. The southern lines were grouped under the name of the Old Colony Street Railway Company, and the northern lines under the name of the Boston & Northern Street Railway Company, the two street railway components of the present Massachusetts Electric Company, and in fact the operators of the north and south sections of the network, respectively.


NEW HAMPSHIRE
Nashua
Haverhill
Newburyport
New Central Stations
Sub Stations
Old Stations
Lawrence
Lowell
Ipswich
Gloucester
ALTERNATIVE LINE
MASSACHUSETTS
Concord
Montvale
Salem
Lynn
Arlington
Chelsea
MASSACHUSETTS BAY
Old Stations
Sub Stations
New Central Stations
High Tension Lines
BOSTON
Quincy
Hingham
Dedham
Rockland
Abington
Brockton
Woonsocket
Bridgewater
Plymouth
Taunton
Providence
Rehoboth
RHODE ISLAND
Fall River
New Bedford
Portsmouth
Newport
BUZZARDS BAY

The effect of this wholesale consolidation has been to unify the rapid transit facilities in the metropolitan district and in the farther suburban regions to a remarkable degree. The process is still going on, and, as will presently be explained, the problem of supplying power economically to this great aggregation of roads is now in prospect of solution. Obviously, while each one of an extensive group of roads may originally have been provided with power by a system correctly designed for that

Cable Terminal Station, Brockton

particular road, so soon as physical consolidation of the groups has taken place, conditions are changed, and the former points of power supply are by no means the most economical which could be selected to meet the new conditions.

From an engineering standpoint the questions thus arising are of great interest, and they are occupying to-day a large part of the attention of the engineers of the organization under discussion. It is to be understood

that the Old Colony Street Railway Company and the Boston & Northern Street Railway Company, although actually closely unified as the Massachusetts Electric Company, are, as operating companies, still in active service, and are united merely through a holding company, although closely enough to secure the practical benefits of a more elaborate system of consolidation.

Quincy Point Station. Interior

The map of this complicated and interesting system will give a clear idea of the nature of the problem of distribution involved in consolidating the generating stations. The great new station at Quincy Point is the main electrical centre of the southern half of the network. The reorganization of the power supply on the northern half has not yet been finally formulated. The Brockton sub-

station is a type of the sub-stations which will be erected at various points over the system. It comprises a neat brick house, with entrance for high tension lines, and, within, reducing transformers, rotaries, and all the necessary switchboard equipment. In the case of this sub-

Quincy Point Station. Interior

station there is a small terminal house shown in one of the cuts, where the high tension lines come in for union with cables joining the lines to the sub-station.

Many of the power houses of the original network were of comparatively small size, and there is excellent opportunity for a large saving in thus distributing power

Quincy Point Station, Massachusetts Electric Companies

from a tide-water station where it can be generated more economically than is possible in isolated stations in the outlying country. As already noted, the northern network will be similarly consolidated, but the work here is not yet thoroughly under way. The whole system is most interesting, as showing the extensive ramifications of the rapid transit system required to connect a metropolis like Boston with the outlying tributary country,

Interior, Brockton Sub-station

and to connect in that country the various centres of population with each other. As regards eastern Massachusetts this task has been accomplished quite thoroughly, more thoroughly, perhaps, than in any similar territory in the country, and the benefits of such unification have already been manifested in a somewhat striking manner. As the work goes on, and the system becomes more and more coherent and coöperative, the beneficial effects of single management will be felt even more strikingly than at present.

The population of the 88 cities and towns served by this organization according to the last census is 1,639,875.

The systems have a total mileage as follows: Old Colony Street Railway Company, 383.22 miles; Boston and Northern Street Railway Company, 487.90 miles; total of 871.12 miles. For the last fiscal year ending September 30, 1903, these companies carried 122,011,604 passengers and operated cars 24,051,621 miles, and its employees numbered 3,834. They have an equipment of approximately 2,000 cars.

As a matter of historical information and also to show the growth of the street railway system in Eastern Massa-

Exterior, Brockton Sub-station

chusetts, it may be of interest to state here the advancement of the original or pioneer companies, making up the present system.

In 1881 these so-called pioneer companies were operating with horses in the cities of Lowell, Lawrence, Haverhill, Salem, Lynn, Brockton, Taunton, and Fall River. The year ending September 30, 1881, the mileage of these Companies was 49.50 miles. The first of the original companies to organize as a street railway corporation was the Lynn and Boston Horse Railroad, which was incorporated April 6, 1859. Its charter called for a

location from the Town of North Chelsea, through Saugus, to the City of Lynn. Very few extensions of track were made by these several companies, until the use of electricity as a motive power had become a known success. On November 1, 1888, the East Side Street Railway Company of Brockton began to operate an electrical line 4.25 miles in length, the cars being equipped with Sprague motors. The City of Salem operated its first electrical line in 1888, Lowell in 1889, Lynn in 1890, and Fall River, Haverhill and Taunton in 1893.

From 1893 to 1896 many miles of track were reconstructed by the old companies, and extensions were made and various new companies entered the field connecting the towns with the cities. So great was the growth of the street railway system at this period that it led the Chairman of the Board of Railroad Commissioners to make the following prediction in his report for the year ending September 30, 1896:

"One can hardly fail to be impressed with the growing importance and magnitude of the service which the electrical railway is rendering the public. It must be accepted as an absolute necessity and an abiding factor in the life of at least the present and the coming generations, and it is to be dealt with as such."

Immediately upon the consolidation of the various properties now making up the two operating companies of the Massachusetts Electric Companies, steps were taken to bring about more uniform methods of operating. Through lines between cities, where they had been heretofore split up on account of divided interests, were run. Greater transfer privileges were granted the public, and in many instances fares were reduced. There has also been an effort made to standardize the equipments of the Companies, and in fact a general reorganization of the various departments of the companies followed the consolidation.

One of the greatest problems which confronted the management of these companies was that of insufficient power. By the consolidation of these various street railways it brought into the system nineteen power stations, which, of course, had a great variety of equipments. In many stations it was found that the original equipments installed a number of years before were in operation. Many

of these stations were poorly located for the proper distribution of the current generated, and early in the year of 1903 it was planned to install a high tension alternating system for supplying current to nearly all of the lines included in the Massachusetts Electric Companies' property, and with this end in view, the Company started immediately upon the construction of a steam turbine station at Quincy, Massachusetts, aggregating fifteen thousand horse-power.

This location was selected as being a desirable one on account of the facilities afforded in the matter of obtaining fuel. It is located on tide water in the City of Quincy on property which has been partly reclaimed by filling, and it is proposed to make extensive additions by building a concrete retaining wall at approximately the line of mean low-water level, utilizing the ash from the power house as filling material.

The station is a combined steel and brick building, one hundred and sixty feet long, one hundred and twenty-one feet wide. The building is now complete. The boilers have all been set and are in operation, furnishing steam to the old Quincy plant which supplies power to the local territory adjoining Quincy, and to a temporary station which is now sending current to the sub-station at Brockton. Work is progressing rapidly on the installation of the turbines and it is expected to have them in operation about September 1, 1904.

It is also proposed to erect a turbine station at Fall River, having a capacity of twelve thousand horse-power, and upon the completion of both the stations, eleven direct current stations will be shut down.

The turbines which are being installed at Quincy are of the Curtis vertical type, made by the General Electric Company.

Both of these central stations will generate alternating current at 13,200 volts, three-phase, twenty-five cycles, and the current will pass at this voltage to the three-phase transformers. The alternating current from the two central stations will be received in nine sub-stations, distributed over the territory so that each sub-station will serve an area of about five miles in each direction from the sub-station location. The size and number of rotary

converters and transformers at each sub-station will be proportional to the load to be carried at each. The 13,200 volt, twenty-five cycle, three-phase current will be received from the transmission line at each sub-station and transformed to 350–370 volt, alternate current for distribution to the rotary converters.

The rotary converters and transformers will be furnished by the General Electric Company, and each rotary will be served by one three-phase transformer instead of three single phase transformers as are commonly used in electric railway work. In other words, the three transformers will be combined into a single piece of apparatus.

The two central power stations will be tied together so that each station can supply various combinations of sub-stations, thus introducing considerable flexibility in running and rendering a complete shut down of any station of the system a very remote possibility.

The nine sub-stations are to be located as follows: Quincy Point, Milton, Rockland, Bridgewater, Brockton, Lakeville, Taunton, Portsmouth, Fall River.

Except in the size and number of units, the sub-stations will be very similar in design to that of the Brockton sub-station, the idea being in each case to simplify the apparatus as much as possible.

The lines north of Boston now receive power from ten separate power stations. Five of these stations will be displaced by one steam turbine station, aggregating nine thousand horse-power, to be located at Danvers, Massachusetts. This location was selected as having the advantage of being located on tide-water as in the case of the Quincy Station. Plans for this development have not yet been fully perfected, and work for the present will be confined to the rearrangement of the power facilities on the lines south of Boston. The accompanying map of the Boston and Northern and Old Colony Companies shows the oldpower stations as well as the three new turbines' stations and the sub-stations, which the main generating plants are to supply current to.

In addition to the three turbine stations here outlined, the Old Colony Street Railway Company has, at the present time, a small combined electric lighting and railway station at Newport, Rhode Island, with three one

thousand horse-power turbo-generators, which was built somewhat as an experimental station for the purpose of determining the best designs for many of the minor details connected with steam turbine work. This station has now been in operation for a number of months, and it can be definitely stated that in spite of minor difficulties which might well be expected at any new station, the Newport plant has been operating in an economical and satisfactory manner.

As to the transmission of the current from the central plants to the sub-stations, the Old Colony Street Railway Company proposes to obtain rights of way fifty feet wide for a distance of about one hundred miles, for carrying the 13,200-volt current. The transmission wires are aluminum cables equivalent to 252,000 c.m. capacity in copper.

Terminal houses are located where it has been necessary to conduct underground cable from the pole line to the sub-stations.

It is proposed to expend for this work of constructing these several turbine stations and transmission lines with sub-stations, approximately three million dollars.

In addition to the above street railway interests, the Massachusetts Electric Companies control and operate the Hyde Park Electric Light Company. This Company does a general commercial and incandescent lighting business in the town of Hyde Park. There is also an illuminating department in the Old Colony Street Railway Company, located in Newport, Rhode Island, which does a business similar to that of the Hyde Park Electric Light Company.

There will be added during the present year to the equipment of the northern system, a large central operating car-house at Salem, which is to displace several small ones. There is also to be erected at Hyde Park a large operating house.

The General Offices of the Company are located at 84 State Street, Boston, and the Division Offices are located as follows: Old Colony Street Railway Company—Hyde Park, Taunton, Quincy, Fall River, Brockton, Newport, R. I. Boston & Northern Street Railway Company—Chelsea, Gloucester, Lynn, Lowell, Wakefield, Lawrence, Salem, Nashua, N. H., Haverhill.

The Edison Electric Illuminating Company

JUST as the rapid transit of Boston and of eastern Massachusetts has been gathered into the custody of a few strong and carefully managed corporations, so the electric lighting of the Metropolitan district has gradually been consolidated, until it is now, for the most part, in the extremely competent hands of the Edison Electric Illuminating Company, of Boston. Small stations for electric lighting suffer in just the same way that small stations for railway power generation suffer, particularly when they are necessarily located away from the sea-coast.

Here in Massachusetts fuel is a serious matter. The costs are high, and unless one can have the advantage of a station on the water front, there will be serious addition to the cost of energy produced by the necessity of transporting coal by rail. Moreover, it is well understood that small lighting stations are extremely difficult to design for a high general level of efficiency, and that consolidation of a number of plants, if physically practicable, is likely to improve the economy of power generation.

Bearing this in mind, the Edison Company has steadily pursued the policy of adding to its territory more and more of the Metropolitan district, extending into it its high tension network, and supplying it more and more from the great central station in Boston. Producing power on the scale there undertaken, it can profitably be transmitted considerable distances in competition with the small lighting plants which previously did the work, and the result has been a happy one. The engineering problems involved in this wholesale distribution are of a most intricate character, because

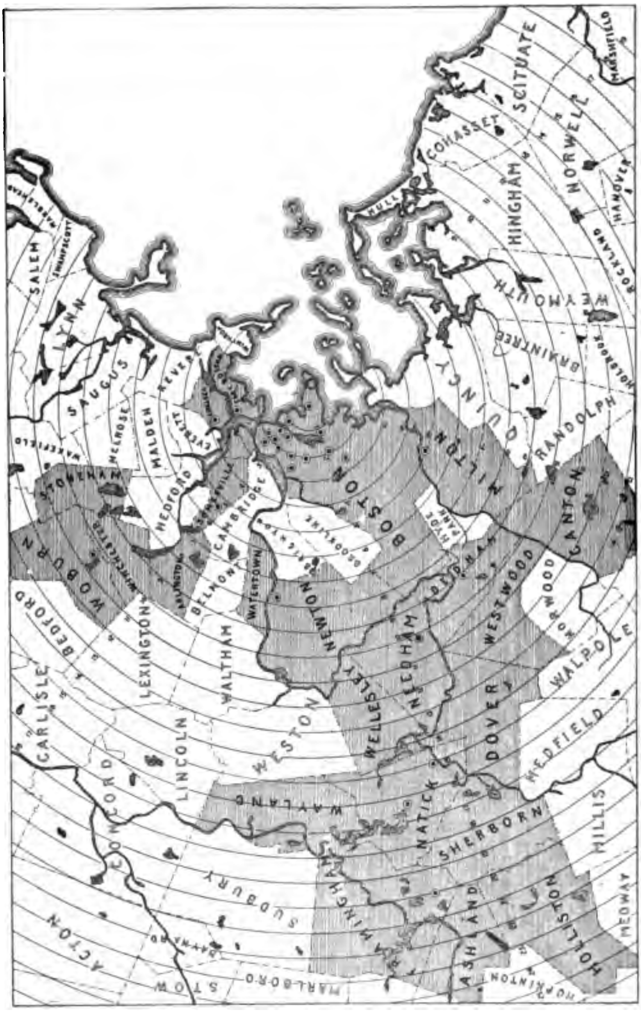


figure 1
Stations Replaced by Edison Illuminating Company

the plants gradually acquired represent almost every conceivable system of electric lighting, operated by almost every method known in the art. The organization of these various services into one general system is a formidable task, but it has thus far been carried out with a very gratifying measure of success.

Of special interest to engineers is the system of generation and distribution organized to replace the diverse systems previously in use. Its centre is the great L Street station in South Boston, and some of the features of this very important installation, together with the story of the growth of the original enterprise to its present colossal dimensions, is an interesting chapter in electrical history.

Exterior, Atlantic Avenue Station

The Edison Electric Illuminating Company of Boston was organized December 26, 1885, with a capital

stock of $100,000, which included the payment of $35,000 to the Edison Electric Light Company, the parent Company for license rights under the Edison patents. This contract for rights limited the operations of the Company to an area of about 70 acres in the business centre of the city. The plant which formed the nucleus of the new enterprise consisted of one 200 horse-power Babcock & Wilcox boiler, and one 90 horse-power Armington & Sims engine, driving two

Low Tension Station, Edison Illuminating Company

Edison type, H-dynamos having a capacity of about 400 lights each, installed originally in the basement of a printing office near the corner of Boylston and Tremont Street.

The Company having then obtained a franchise from the city, moved this modest initial plant into a two-story brick building, the lower floor of which had been previously used as a stable and the upper one as a tenement. This station was started on February 20,

Figure 2

Generating and Sub-stations, Edison Illuminating Company

1886, and the first customer to be supplied with electricity for lighting was the Bijou Theatre on the occasion of a production of "Iolanthe."

This station in Boston was probably the first general power station of any size in the world, as previous to this time there is no record of more than a few motors being operated from a single plant, while the Boston station by 1887 was supplying current to 92 motors with an aggregate capacity of 300 horse-power.

The Edison Company of to-day, grown to a corporation of $8,635,500 capital stock, with 19,000 customers, occupies exclusively a territory of approximately 290 square miles, having, in the course of this extension, acquired through various purchases and consolidations 13 original companies, operating some 26 independent steam and water power plants.

It would be unprofitable to go into the intermediate steps leading up to the consolidation and combination of the various distributing systems and to the final wiping out of all but two generating stations. The result of these operations is best shown in the annexed maps, the first of which shows the approximate locations of the various generating stations of the different companies, while the second shows the two generating stations and various transforming stations of the present Company for supplying the same territory.

The distribution system for the entire territory may be roughly divided into two parts. The Edison low tension system supplies all the current for lighting and power within the limits of the city proper, an area of approximately 8.8 square miles. The remainder of the territory is supplied with alternating current exclusively. The Edison low tension plant for the city district is situated on the water front of Atlantic Avenue It has a capacity of 12,000 k.w., supplemented by a storage battery of 1,456 k.w. hours. The area supplied by this station is included within a circle having a radius of about 4,000 feet. The balance of the low tension district is supplied through sub-stations, receiving their supply from the great alternating plant

Main Generating Station, Edison Illuminating Company

in South Boston. All sub-stations in this territory are equipped with motor generators, backed up by storage batteries. The total storage battery capacity installed in this district amounts to 5,788 k.w. at one hour rate, being about 48 per cent of the maximum demand for low tension current.

The present high tension alternating plant just referred to supplies current for all the outlying territory. This station has a capacity of 10,500 k.w. in three-phase generators of 1,500 k.w. each, at 2,300 volts and 66 cycles.

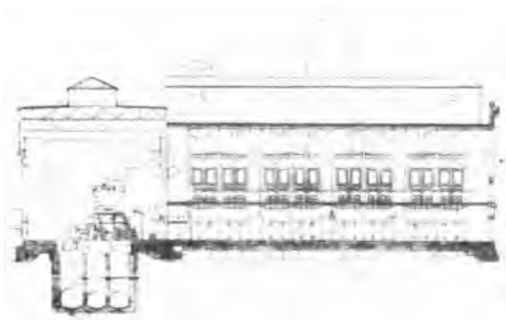
Immediately adjacent to this station the Company is just completing a plant to be equipped with turbine generators. As this is an entirely new type of apparatus for this country, a rather complete description of the plant is worth giving.

The station is planned for an ultimate equipment of twelve 5,000 k.w. units. Two of these are being installed at present, and the building is large enough to hold two additional units. The building is of steel frame construction, finished on the interior with enamelled brick and Grueby tile, the turbine room being 68 feet wide, 650 feet long, and 56½ feet high. It is the intention to divide the completed station of 12 units into three entirely separate rooms of 4 units each, in order to minimize disturbances due to possible accidents of any kind.

Beneath the turbine room floor and running lengthwise in the centre of the building are three brick tunnels for conveying cooling water to the condensers. Two of these are suction or intake tunnels with cross sections of about 56 square feet each. One will run the full length of the completed building and the other one-half the length. Six of the turbines are to be supplied from each tunnel. The third or discharge tunnel will run the full length of the building with a cross section of 78 square feet, and will discharge the water for all the turbines. Two intake tunnels were provided to facilitate cleaning out when necessary. The tunnels are all built of horseshoe section and

consist of three ring arches of sewer brick incased in concrete envelopes 2 feet thick.

The bottom of the tunnels is at grade — 13′ 6″, being 29½ feet below the turbine room floor. Connection is made with these tunnels by six groups of manholes, each group being located centrally between a pair of turbines. The tunnel intakes have an elaborate construction of concrete at the sea wall, with gates and screens. There is also a timber bulkhead running out 80 feet beyond the sea wall to prevent the discharge water from mixing with the incoming water.



Elevation, L Street Station

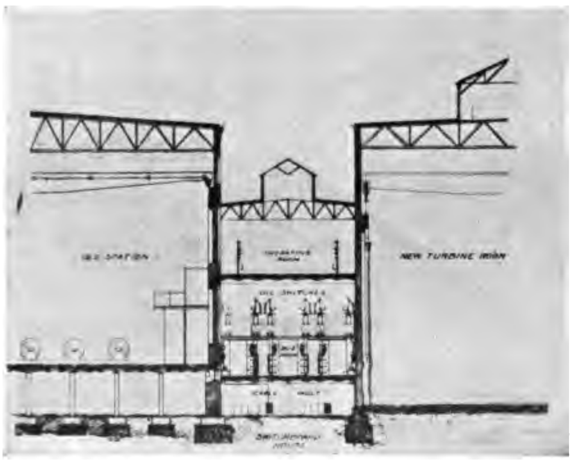
The boiler room for the present plant occupies a building 149 feet wide by 640 feet long. The basement or ash room floor is on the same level as the turbine room floor, the boilers themselves being set on the second floor, 18 feet above. A portion of the ash room floor surrounding the chimney is walled off and reserved for all the main piping of the boiler house, where it can be kept free from dust, and reasonably warm. The boilers are grouped differently from old

station practice, in that the requisite number of boilers to supply one turbine are grouped in a row at a right angle with the turbine room, the main steam pipe running under each row of boilers and going directly to the turbine in line with that row.

These different mains are connected by cross pipes, which will normally be kept closed, but which will make it possible to run a turbine from an adjacent battery of boilers. Above the boilers and practically above the roof of the main portion of the boiler house are coal bunkers to hold 44 tons of coal per boiler. These are made of reinforced concrete walls. Above these coal bunkers is a rubber belt for bringing in coal from the storage yard. Between each two rows of boilers, and central with the rows, is located a chimney for two groups, six chimneys being planned for the completed station. These are built of hollow radial brick, 250 feet high, and 16 feet internal diameter at the top without lining. Each chimney is equipped with external and internal ladders and lightning rods. It is the intention to divide the completed boiler house into separate sections in the same manner as described for the turbine room.

The switch house is located between the turbine room and the old station, and is entirely separated from the turbine room. One end of the switch house is reserved for a few necessary offices in connection with the operation of the plant. The balance of the building is divided into three floors. The first is a cable room where the various cables from the generators and outgoing feeders are terminated in two rows, running lengthwise of the entire building, immediately under the switches. The second story is occupied by the bus bars, and the third by the high tension oil switches. For a distance of about 120 feet in the centre of the switch house another story is added for the operating room, containing all the instruments and controls for the various switches and regulating mechanisms. Nothing but low tension current is brought to this floor.

The total area covered by these buildings is 160,000 square feet, giving 2.66 square feet of ground per k.w. capacity, as compared with 1.27 square feet for the Metropolitan Station in New York and 0.96 square foot for the station of the New York Edison Company. There has been provided an open-air storage yard for coal, with a capacity at the present time of from 60,000 to 70,000 tons, and capable of being increased to double that amount when needed. This large storage is provided that it may be possible to receive all the



Section, L Street Station

coal during the four summer months when freights are low, and also as a protection against delays due to storms or strikes.

On the wharf there are two discharging towers for coal: one equipped on the Ward Leonard system, with a capacity of about 600 tons of coal a day, the other with a capacity of about 1,000 tons of coal a day, operated by hydraulic cylinders, supplied by a high pressure centrifugal pump, driven by an induction

motor. These cylinders operate under a pressure of about 200 pounds to the square inch. Coal is carried from the wharf into the storage yard and into the station by endless rubber belts, and is distributed over the storage yard or brought back to the belts by means of a large travelling crane, covering the entire storage yard. This crane is 238 feet long, and is operated by 500-volt direct current motors. The boilers of the new plant are Babcock & Wilcox, rated at 512 horse-

Generating Station, Edison Illuminating Company

power each, built for 225 pounds pressure, equipped with Roney mechanical stokers, of 110 square feet of grate surface each, and operated by induction motors.

No economizers are being installed at present. Provision has, however, been made to permit their installation on future units when it is demonstrated that they will pay under the existing conditions of service. The turbines are furnished by the General Electric Company, Curtis type, 4 stage, and have surface con-

densers installed directly on their bases. A detailed description of these machines seems hardly necessary here. They occupy each a floor space somewhat less than one-half that required for one of the 1,500 k.w. units in the old station. The generator for each is a 60-cycle, three-phase, revolving field machine, wound for 6,900 volts. This voltage was adopted as a multiple of the 115 volts supplied to all the low tension services.

Turbine Station, Edison Illuminating Company

The turbines run at 514 revolutions per minute, and weigh 115 tons above the condenser. The condensers are of the surface type, each of 20,000 square feet surface, with four passes for the circulating water. The condenser tubes are of brass, one inch in diameter and 16 feet long. Circulating water for each condenser is provided by a 24 in. centrifugal pump, direct driven by a horizontal simple engine at 250 revolutions a minute. The vapor of condensation is removed by means of one

rotary dry-air pump, also steam driven. The water of condensation is removed by a 4 in. centrifugal pump, placed below the level of the bottom of the condenser. The boiler feed pumps are placed in the turbine room with the other auxiliaries. They are horizontal, centre packed plunger, duplex pumps with water plungers 12 in. in diameter, and 15 in. stroke. One pump is provided for each boiler room installation and one spare pump for the entire installation.

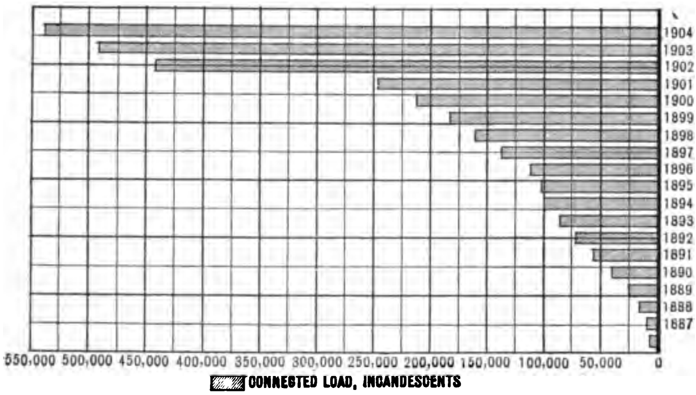
The step bearings for the turbines will be carried on water under a pressure of about 900 pounds per square inch. This pressure will be furnished by horizontal, steam driven, duplex plunger pumps, with a 12 in. weighted accumulator for each turbine. The water of condensation will all be returned to the boilers. The high pressure steam system is of steel pipe throughout, with gun metal fittings and valves. All important valves of the system are so arranged that they can be operated from two points which are separated from one another by a solid wall. The large valves are all operated by motors.

Passing now to the switch house, the bus bars are in duplicate, each feeder being equipped with two selector switches and each generator with two selector switches and one main switch. All oil switches are operated by motors. The bus bars are bare aluminum, incased in brick cells. All wiring not carried in ducts in the floor is covered with flame proof braid on the outside of rubber. Provision is made for cutting the bus bars into sections by means of oil switches in order that it may not be necessary to run all the generators in parallel, if it should be found that troubles due to burn-outs would be lessened thereby.

Excitation for the generators is supplied at 125 volts by motor generators, backed up by a storage battery of 1,000 amperes capacity at a one-hour rate of discharge.

The old station adjoining this new plant operating at 2,300 volts, 4,500 k.w. capacity in transformers has been installed for connecting the 2,300-volt bus

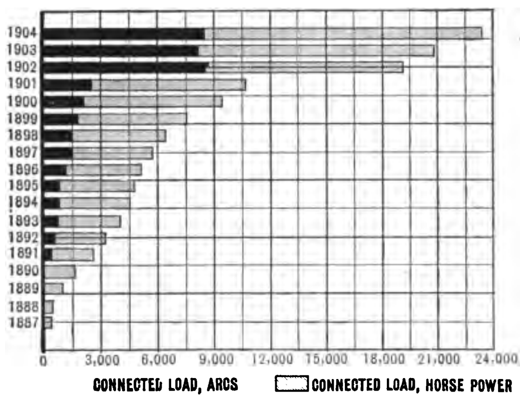
bars with the 6,900 volt system. It will probably be some time before it will be necessary to run both these stations through the entire 24 hours. Current is distributed from the alternating plant to all of the substations in the Edison district by means of three-conductor underground cables. All cables now being installed are insulated for 6,900 volts. Current is carried to the outlying district by means of underground cables through the city proper, and beyond that by



The Growth of Incandescent Lighting

means of overhead wires of aluminum. Three trunk lines are being constructed, one for the southern district, one for the western, and one for the northern, the longest transmission being 27 miles. All these latter installations are being constructed for 15,000 volts, and all sub-station transformers are constructed with double windings, so that the pressure may be doubled when business demands it. The present tie transformers between the 2,300 and 6,900 volt stations are arranged for connection to give 15,000 volts when needed. The pole lines are constructed of chestnut poles, 8 in. in diameter at the top, equipped with triple petticoat, glass insulators, and the wires are spaced 30 in. on centres. The three wires for each phase are arranged in a vertical

plane, so that all wires on any one cross arm are of the same potential. It was thought that this might give some additional security against short circuits due to anything falling across the line. All high tension switchboards in the sub-stations are equipped with oil switches, and are built in cellular form. The annexed diagrams show the growth of the different classes of service. The gross income of the company for the year 1904 was $3,125,516.



Increase of Arc Lights and Motors

Electrical Manufacturing

ASIDE from the large operating companies, Boston has no small number of diversified electrical industries. The large electric manufacturing companies elsewhere in the country maintain offices here to take care of the New England trade, and, in particular, the General Electric Company and the Westinghouse Electric and Manufacturing Company maintain district offices, with a large sales and engineering force actively engaged in meeting the electrical demands of New England.

Although this territory has been steadily developed from the beginnings of electrical work in this country, the field is very far from being exhausted, and numerous and large installations are yet to be made.

The manufacturing business of the large companies is, however, for the most part carried on elsewhere, save for the Lynn works of the General Electric Company, which themselves form an industrial group of the first magnitude, and which are interesting as being the original seat of the old Thomson-Houston Company, and as having in this capacity taken a very large part in the development of the arc-lighting and electric traction fields throughout the country.

THE LYNN WORKS OF THE GENERAL ELECTRIC COMPANY

The Thomson-Houston Electric Company — which had for its principal factory the works in Lynn, until the consolidation in 1892 with the Edison General Company, forming the General Electric Company — was one of the pioneer enterprises based upon the business of series arc-lighting. It was, in fact, the successor of the American Electric Company, which had been

organized in New Britain, Conn., in the year 1880, for manufacturing under the patents of Professors Elihu Thomson and Edwin J. Houston; such patents relating chiefly to apparatus used in series arc-lighting. The particular system became known as the Thomson-Houston system, among the chief distinguishing features of which was the constant current regulator, which enabled a predetermined current to be maintained on the line, despite the variations of load, and which also allowed the arc-lamps to be standardized or permanently adjusted to work with a standard

The Old Thomson-Houston Works, New Britain, Conn.

current. They thus became readily interchangeable from one circuit to another.

In 1882 the control of the business was obtained by a number of Lynn capitalists, and in the following year the factory was transferred from New Britain to West Lynn, Massachusetts. The enterprise then occupied the building consisting of a three-story structure, situated on Western Avenue, Lynn, which building is

still in use under the designation of "Factory A." When the work was started in Lynn, the floor space occupied was not more than 27,000 sq. ft., and there were only 45 employees engaged in the manufacture of arc-lighting apparatus.

It was at this time that Mr. C. A. Coffin — who has for many years been at the head of the business, and is now President of the General Electric Company — became connected with the enterprise.

THE OLD THOMSON-HOUSTON FACTORY AT LYNN, 1884.

The First Thomson-Houston Factory, Lynn, 1884

The development of the business took place very rapidly, in the hands of the energetic Lynn management, and while it originally related almost entirely to the Thomson-Houston arc-lighting system, it was soon extended to include the various departments of electrical engineering. In the arc-lighting field alone, within eight years after the Lynn management began work, the number of arc lights installed had increased from a few hundreds to 80,000 or more, and this number is now being produced annually.

In succession, the business of manufacturing series incandescent lamps for constant current circuits, in-

candescent lamps for direct current constant potential circuits, alternating current lamps, alternating current lamps with transformers, electric railway apparatus and marine, power and mining apparatus of all kinds were taken up, and factory after factory was added to the original plant, and the increase has steadily kept up until the enormous manufacturing plant of the General Electric Company, now existing at Lynn, has been developed.

During this great industrial development, many inventions were brought out by the inventors and engineers of the Company, and the technical work undertaken became recognized as being well in the forefront of electrical engineering development. This period referred to, marked the inception of many of the devices, the use of which in later years has been extended in a very large way, such, for example, as the electric meters, first brought out in 1889.

General Electric Works, Lynn, 1893

It was in 1892 that the Edison General Electric Company, working under the Edison patents and system, was merged with the Thomson-Houston Electric

Company, to form what now is the General Electric Company, having its principal works and office at Schenectady, New York. Before this consolidation of interests, which was of great importance in the electrical field, the Thomson-Houston Electric Company had already acquired the Brush Electric Company at Cleveland, Ohio, and had incorporated the Brush business with its own. It will be remembered that the Brush Electric Company was the first company to exploit series arc-lighting, under the patents of Mr. Charles F. Brush.

The present plant at Lynn employs about 6,000 hands, being second in size of the works controlled and operated by the General Electric Company, and its productions are of great importance in the business of the Company.

Owing to local conditions at Lynn, the plant is at present subdivided into three groups of buildings. These are known as the West Lynn Works, the River Works, and the Incandescent Lamp Factory, and they cover a combined area of about 80 acres, with a floor space of about 1,200,000 square feet.

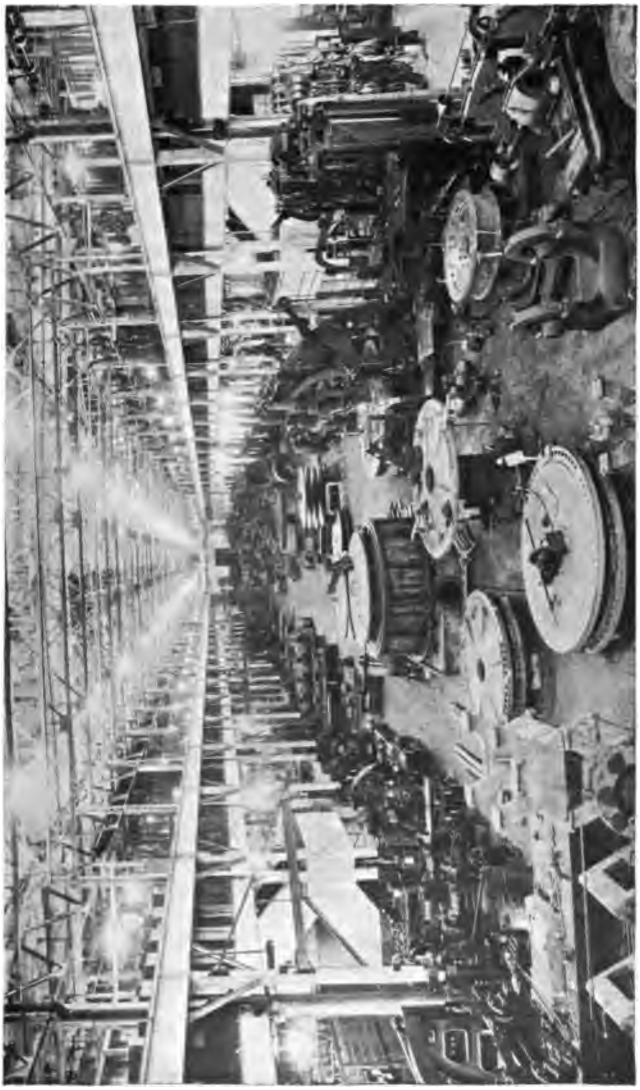
The initial plant, greatly extended and known as the West Lynn Works, covers about 10 acres, with a floor space of something over half a million square feet. It is devoted largely to the manufacture of moderate and small-sized apparatus, such as arc-lamps, arc-dynamos, electric meters, measuring instruments, alternating and direct current fan motors, small and moderate sized alternating and direct current stationary motors, generators of moderate capacity, electric heating apparatus; and general supplies, such as insulated wire, built-up mica, and other insulating materials. This factory has the distinction of having the largest output of the above mentioned classes of apparatus of any manufacturing concern in the world.

The "River Works," as it is called, is about a mile from the West Lynn plant and is situated on the east bank of the Saugus River, which is a tidal stream and

furnishes adequate water freight transportation, and is auxiliary to exceptional railway facilities. The first buildings of this large plant were the iron and steel foundries, erected in 1894. In the iron foundry iron castings are made for the general manufacture, and in the steel foundry heavy and light steel castings are produced on a large scale. It is worthy of note that the steel foundry at the River Works at Lynn was probably the first foundry specially devoted to the production of steel castings solely for electrical machinery.

Gradually the nucleus formed by these foundries became surrounded by a growth of buildings devoted to many other branches of the work, so that the total floor area is now approximately 652,000 square feet. Here are located the general carpenter shop of the Lynn factories, the pattern shop, the large general machine shop, with the most modern equipment of tools, etc., and the insulation department, devoted to the various treatments and preparations which enter into the other manufactures to secure high insulation. Here also will be found the punch-press department, where all the stampings for the rest of the works are made, such as transformer stampings, motor and generator armature stampings and the like. Here also are presses for forming sheet metal into various shapes. The manufacture of railway motor equipments and transformers is also carried on in a group of buildings at the River Works. A recent addition to the plant in the form of a huge steel-frame building, having a floor area of 140,000 square feet, is nearing completion. This building is to be devoted to the manufacture of the Curtis Steam Turbine in sizes ranging from 1½ to 1,500 k.w. capacity.

The manufacture of incandescent lamps in Lynn was started by the Thomson-Houston Electric Company about the year 1885, in one of the early additions to its original plant. This was continued with enlargements up to the time of the union with the Edison



Machine Shop, River Works, General Electric Company

General Electric Company in 1892, and soon thereafter the incandescent lamp business of the General Electric Company was concentrated at its large lamp works at Harrison, New Jersey. It is interesting to note that in the past two or three years the General Electric Company has again established a portion of its incandescent lamp business in Lynn, and there is now in operation a factory, the capacity of which is 20,000 lamps per day, and additional facilities are being provided for a much larger production. In this factory, all the manifold operations which are involved in the production of the complete incandescent lamp are carried on.

It was the policy of the Thomson-Houston Electric Company — and this policy has been continued by its successor, the General Electric Company — to devote a certain portion of its energies to the development of new inventions and designs.

To this end, facilities have always existed in the Lynn Works, as also in the Schenectady Works, of the Company for the experimental development of new apparatus. In this way the Lynn Works has contributed largely to the art in the new devices and inventions from time to time developed by the Company's engineers.

From the first, the policy of the Thomson-Houston Electric Company was that of recognizing merit in other enterprises, and securing control of the important ones, whereby its business was widely extended throughout the country. For example, Mr. Charles J. Van Depoele had, as early as February, 1883, been doing pioneer work in the propulsion of street-cars and exhibited an electric railway in Chicago; at the exhibition in Toronto in 1884 he had operated a conduit electric railway; and in 1885 the Toronto road was operated by an overhead conductor, with an underrunning trolley. In 1888 the Thomson-Houston Company purchased the patents of Mr. Van Depoele, and secured his services. From that time the Company

became a very considerable factor in the electric railway business, and the plant at West Lynn was largely devoted to the supplying of railway motor equipment and power station equipments required in the business.

It will be remembered that the first direct connected d.c. 500-volt, 1,500 k.w. generator was installed at the World's Fair in Chicago in the operation of the Intramural Railway within the exhibition grounds. The parts of this large generator were built in Lynn and were assembled for the first time in the power house at the Exposition.

Some idea of the growth of the works at Lynn may be obtained from the statement that in 1892 the floor space occupied had increased to 350,000 square feet, and the number of employees had risen to over 4,000.

The American Telephone and Telegraph Company

THE RISE OF THE TELEPHONE

BOSTON is preëminently the Telephone City. It is the birthplace and early home of the telephone, and is, and always has been, the headquarters of the telephone business in North America.

Before the year 1876 there was not a single speaking telephone in the hands of the public anywhere in the whole world. When that year opened, though Alexander Graham Bell had previously discovered the fundamental principles of the telephone, had invented the art of electrically transmitting spoken words, and plans for practising it, and though he had even made telephones exemplifying such principles, no patent protecting the invention had as yet been granted to him; no one except the inventor had ever made or used the instruments; and such suggestions of transmitting conversation over wires by means of the electrical current as had perchance made their appearance were either disregarded altogether, or, if considered at all, were by press and people alike treated as an excellent joke.

But now in the year of grace, 1904, everyone knows, in a general way, what the telephone is; what the telephone exchange is; and that this wonderful means of electrically transmitting thought and communicating intelligence from one place to another is universally employed and made available in almost every city and considerable town of every civilized country.

The invention of the telephone was the result of the fortuitous combination of the right man, an appropriate environment, and a special training; and admirably exemplifies the truth that while for the accomplishment of such special work, energy, aptitude, and perseverance are

essential qualifications, their value is immeasurably increased and the chances of success infinitely enhanced, if to them are superadded the special equipment of special training and education; the conviction that the object sought is attainable; and the determination to attain it.

Perhaps no man ever was so well equipped as Graham Bell for making an invention. Certainly no man could be better equipped for the making of this particular invention. His father, Alexander Melville Bell, was a professor of vocal physiology, and he himself had been trained and educated from boyhood to the same profession. He had been familiar with the operation, the constitution and nature of speech for many years, and as a boy had made a mechanical talking machine.

Born and brought up in Scotland, young Bell — then twenty-three years old — moved with his parents to Canada in 1870, and ultimately in 1872 to Boston, where he lectured upon vocal physiology at Boston University, besides giving lessons to private pupils. Much of his work consisted in teaching deaf-mutes to talk; that is, to carry on conversation orally, although they themselves could not hear it, a thing which seems much more difficult now than the electrical transmission of speech; and we need not wonder that he grew to mentally see the movement of the air particles which constitutes sonorous vibration. Nor, considering the manner of man he was, is it to be wondered at, that since the time for the appearance of the speaking telephone was now at hand, he should be the discoverer of the important and essential fact that the current flowing in the line between a transmitting and receiving plate or membrane must be an electrical copy of the vibrations of the original sounds, — must, to use his own words, be "similar in form to the vibrations of the air accompanying" such original sounds, — in order that the motion of one of the plates should control that of the other, and that the motion of the controlled plate should in every respect be a copy of that of the controlling one.

A clear conception of the nature of the problem, and a plan for its solution, certainly presented themselves to

the mind of Mr. Bell during the year 1874, and in October of that year he imparted his ideas to a friend; but here for the moment he was stopped by the apprehension that any working currents generated on the plan he had in mind (which in substance involved the magneto-electric apparatus he subsequently developed) would probably be too feeble to produce practically useful results.

Now the telephone was not the only matter in addition to his regular duties that our inventor had on hand at this time. He was also engaged with inventions in harmonic multiple, and autographic telegraphy, and being too poor to prosecute his researches independently, had entered into an arrangement with certain gentlemen (one of whom, Mr. Gardiner G. Hubbard, subsequently became his father-in-law), under which they should pay the expenses of experimenting with these telegraphic inventions and of obtaining United States patents for them, while he should give up a portion of his professional work and give the time thus saved to telegraphic experimentation. These gentlemen, who thought something could be made out of the telegraphic inventions, but had no faith in the speaking telephone, and regarded it as being wholly chimerical and fantastical, naturally wished to push the multiple telegraph invention forward, and discouraged work on the latter.

Mr. Hubbard, telling the story of the relations between himself and Mr. Bell at that time, remarks with some naïveté that he had "no belief in Mr. Bell's ability to transmit vocal speech," and that he thought he was wasting his time in allowing his mind to dwell upon that subject, which certainly could never be made commercially valuable; and ought to spend more of his time upon "instruments that would transmit many musical notes simultaneously, or upon an autograph telegraph at which he was working; as such instruments would be of more value than any instrument for transmitting speech."

It need not therefore be a matter of surprise that Mr. Bell halted before the apparent difficulty of the excessive feebleness of the magneto-electric current for some time, since he was not an electrician of skill and experi-

ence, but rather, as Maxwell has well said, "a speaker, who, to gain his private ends, has become an electrician;" since he had many other matters to attend to, including that of earning his living; and since he had financial backers urging him in the direction of multiple telegraphy, and deriding the thought of profitably transmitting speech.

But while temporarily blocked, Mr. Bell did not waver in his convictions, and continued to think and watch. On June 2, 1875, the casual observation of the unexpectedly vigorous way in which a reed vibrated in correspondence with the enforced vibrations of a similarly tuned reed at another part of a circuit, and under accidental conditions, at once carried conviction to the trained mind that the apprehended difficulty was imaginary, and was speedily followed by the construction of the first pair of magneto telephones. These each consisted of an electromagnet having a U-shaped iron core, a coil round one limb of the core, a thin iron armature hinged to the other limb and stretching across the pole-surrounded core, and a membrane diaphragm stretched across a tube serving as a mouthpiece and mounted in a frame with its centre immediately opposite the active pole of the magnet, and with the armature mechanically attached to its centre.

These were the first telephones. Their immediate success was not very great, the reason, as we now know, being threefold: no one knew what the reproduced sounds of the telephone would be like, and the still small voice it really did possess being unexpected, remained for the time unrecognized; the place where they were tried, a workshop, was in any event too noisy for inexperienced persons (and every one was inexperienced then) to hear the sound of the voice reproduced by a telephone receiver; and the art of constructing telephones being just born, the instruments were mechanically bad.

Bell, however, was now sure of his ground; the results he obtained were sufficient to keep him steadily at it from this time on; and the instruments of the summer

of 1875, tried at a later period in a quieter place, and after the experimenters had obtained some experience and knew what to expect, turned out to be really good, practical telephones.

During the remainder of 1875, the inventor applied himself in the first place, to making trial of every imaginable variation in the proportioning and arrangement of the coil, magnet, and armature, of instruments of this sort; and secondly, to the work, undertaken and carried out solely by himself, of preparing appropriate descriptions of the telephone invention for the application for his original United States Patent.

The application for the patent was filed in the Patent Office on February 14, 1876, and the patent when granted on March 7 of the same year bore the number of 174,465. After an eventful life of seventeen years, during which time it bore with invariable success the brunt of a litigation unexampled in the annals of patent law, it expired on March 7, 1893. The form of telephone described and illustrated in the patent specification had not advanced very far beyond that of the instruments of June, 1875, but there had been added hollow cones attached to the armature membranes to direct the impact of the voice upon the membrane in one instrument, and towards the ear of a listener in the other.

The first account of the speaking telephone and its powers presented to the public was given in Boston on May 10, 1876, in a paper read by Bell before the American Academy of Arts and Sciences; and from this we learn that the fashion of using a relatively heavy armature, and of hinging it to one pole of the magnet, had already gone by; and that its place was taken by a small patch of clock-spring steel glued to the membrane centre, close to but without touching the magnet pole carrying the coil. Articulate speech clearly understandable, and sometimes surprisingly distinct, was obtained on a circuit containing a battery of, say, about ten volts E. M. F. and extending between two rooms at a distance from one another in the same building, by means of two magnet instruments of this kind. A variable resistance transmitter

sometimes having a wire attached to the membrane and dipping into acidulated water, and sometimes a small carbon cylinder similarly carried on the membrane and dipping into mercury, was also spoken of, as having been devised and experimented with; and the accounts given of it show that while the inventor clearly had at that time a preference for the magneto transmitter operating by the development of currents of variable electromotive force, probably for its extreme simplicity and for the stability of its moving parts, he had in mind variable resistance transmitters also.

It was at this stage of its development that the telephone was exhibited at the Centennial Exposition held at Philadelphia in the summer of 1876 to commemorate the completion of the first hundred years of the national existence of the United States.

Its exhibition there was the beginning of its public career. There, its capabilities and the remarkable results of its operation attracted the admiring attention of many distinguished votaries of science; and it was the recipient of much appreciative acclaim and laudatory remark from Professor Joseph Henry and Sir William Thomson (now Lord Kelvin) of the board of judges of the scientific section.

It cannot be doubted that this early acknowledgment by the highest scientific authority, of the surpassing magnitude and importance of the discovery as a scientific achievement, and the far-reaching possibilities of the invention, made it at once celebrated, and brought it prominently before the public eye, creating for it a general and widespread interest, which apart from this noteworthy occasion would have been less expeditiously secured; and which materially facilitated the task of practically introducing it into active employment as a useful, efficient, and simple means of reciprocal communication over the electric wire.

With one exception the telephone instruments exhibited at Philadelphia were of the same simple construction as had been described by the inventor to the American Academy of Arts and Sciences, consisting of a stretched

membrane having a little piece of iron attached to its centre, and thus held closely confronting the pole of an electromagnet; these instruments being used indifferently to transmit and receive. The exception was a particular form which at the Exhibition was operated as a receiver only, and which therefore has received the designation of the "Centennial Receiver." This instrument, dispensing altogether with the stretched membrane, was formed of a tubular electromagnet whose coil surrounded an iron core and was enclosed in an iron tube. A thin, circular piece of sheet iron served as armature and vibrating plate, and rested by its edge upon the rim of the tube, its middle part not quite touching the end of the central iron core. This instrument is of historic interest, as being the first speaking telephone with a metallic diaphragm; and was the direct forerunner of the iron diaphragm commercial telephone instrument which is still universally employed as the receiver.

Stimulated by his Centennial success, the inventor of the telephone devoted himself during the latter half of 1876 to its improvement with redoubled ardor, and made many structural advances, which for the most part he sought to describe and protect in a second patent granted to him on January 30, 1877.

In the Exhibition displays and in all telephone work up to the summer of 1876 we find Bell employing electromagnets for his telephones, and using a voltaic battery connected in the line circuit to establish a constant line current. Now, however, he begins to cast about in the direction of simplification, and he shrewdly suspects that the only material function of the battery is to excite his electromagnets.

He writes to a friend on July 2, 1876: "I am sure by substituting a permanent magnet for the pole of the electromagnet I could work it without a battery at all." This, indeed, had been the original idea of Mr. Bell in 1874, but with the instruments thus far made, the effects obtained had been more powerful with a battery in the line; or so he had fancied. A permanent magnet instrument was now, however, made and tried, and, as had been

anticipated, it was found that the essential thing was the presence of the magnet howsoever produced. Accordingly, after confirmation of these results by many experiments the battery was towards the end of the year finally eliminated, and the permanent magnet generally employed.

The diaphragm also received consideration, and many hundreds of experiments were made, with the object of determining once for all the best size, thickness, and shape. Now that the telephone had actually been made to talk, it was found difficult to make it so that it would not; and the size and thickness were varied between wide limits without seriously affecting its talking powers. Generally, it was ascertained that keeping the thickness the same, the articulation remained good with diaphragms of all sizes, say from a diameter of six inches down; but that the tone with the largest sizes became resonant or cavernous, and with the smaller sizes nasal, or Punch-and-Judy-like. But it was also ascertained by repeated trials with the membrane diaphragm having the patch of iron glued to its centre, that the bigger the patch of iron was made, the better the telephone worked, and the more distinct grew its articulation. The iron patch ultimately grew so large that it became obvious that the membrane was superfluous; it was therefore discarded entirely, the simple sheet-iron diaphragm henceforth taking its place in all instruments made.

The coil, as a result of many trials, was shortened until it became the thin bobbin now a characteristic feature of receivers; and it soon became clear, that quickness rather than strength of action was required; and that it was a distinct advantage to have the coil just long enough both as a winding and as a spool to act effectively upon the extreme end of the magnet nearest the diaphragm, and an equally distinct disadvantage to have it any longer.

The resonating space within the speaking or hearing tube and in front of the diaphragm was made thin and flat, and thus brought into line with well-established acoustical principles. It was demonstrated that the size of a telephone instrument could be extensively varied

without interfering with its operativeness or efficiency; and this permitted the employment of a small bar or U magnet enclosed in a handle in portable form, such as is used to this day. Still later, a soft iron polepiece screwed to the end of the hard steel permanent magnet within the coil was adopted.

A great advance in effectiveness over the "Centennial" instruments followed and resulted from these alterations. The talk reproduced by the receiver was much louder and clearer; the telephone, no longer a mere scientific triumph and toy, had become a practical success, and was ready for introduction to commercial life; its inventive work was completed; and it remained only to devise forms most suitable for practice, and most convenient for the public.

Before the autumn of 1876, while much talk had been transmitted by telephone over electric circuits, every communication had been sent and received between places in the same building and under one roof; and no message had been transmitted over a real line connecting two stations at a distance from one another. As early as August of that year Mr. Bell, while paying his annual visit to Canada, experimented upon a five-mile telegraph line between Brantford and Mount Pleasant, Ontario, and probably transmitted some short sentences and several songs; but no very tangible account of the affair is recorded.

He is soon, however, again in Boston, and that the telephone — notwithstanding the minuteness of its current — would work well on a real line supported on poles in the open air, was demonstrated beyond peradventure on the evening of October 9, when the first long conversation ever carried on by word of mouth over a telegraph line, was transmitted upon a line owned by the Walworth Manufacturing Company, extending from their office in Boston to their factory in Cambridge; Mr. Bell being at the Boston end, and his assistant in Cambridge. Every word of this conversation was recorded at both end stations; and from that time there was no longer room to doubt that the telephone could be made practically useful.

The telephone even in these archaic times was not restricted to short lines; and on November 26, 1876, it was experimentally employed as a medium of communication between Boston and Salem, Massachusetts, by way of North Conway, New Hampshire, about two hundred miles of actual line wire; and at a later period Mr. Bell and his associate exchanged conversation over a Western Union Telegraph Company's wire between Boston and New York; both of which performances would even in these later days be accounted good work for a magneto transmitter.

Early in 1877 the inventor and his friends made active efforts to give publicity to the invention, and to attract attention to its promise. Mr. Bell gave lectures in many places, including Boston and New York, publicly exhibiting the telephone and exemplifying its operation at each one. This was done to prove to the public the operativeness and practicality of the apparatus, and incidentally to raise money for its commercial introduction. Mr. Watson, the associate of Mr. Bell from the beginning, remarks upon "the great doubt that existed in everybody's mind, when first spoken to about the telephone, as to whether it was possible to do such a wonderful thing as to transmit articulate speech over a telegraph wire."

Every possible effort was at this time made to excite a general interest in, and familiarize the public with, the new invention.

Mr. Gardiner G. Hubbard, in whom, as trustee, the telephone patents had been vested, had many instruments made and distributed as loans to telegraph and other companies and individuals, to attract enlightened public attention, and to influence capital for the commercial introduction of the telephone.

Agents were appointed and given power to lease telephones, receiving a commission on each; and before April 1, 1877, an arrangement was made for their manufacture. It was, however, uphill work at this time.

Still, progress was made; and in the early spring a line was erected in Boston (the first telephone line ever built) for the express purpose of establishing regular

telephonic communication between the factory of Mr. Charles Williams, Jr., the manufacturer who had been engaged, and his residence at Somerville. This line was finished and put in operation on April 4, 1877, and was mentioned by several of the Boston newspapers on the following day. Numbers of people came to see and try it, and orders began to come in for telephones and telephone lines.

Before the end of April other telephone lines were constructed, connecting Professor Bell's own laboratory, No. 5 Exeter Place, Boston, with the factory of Mr. Williams, and other points in Boston, and the office of Stone & Downer (now Downer & Co.), 28 State Street, Boston, with the house of one member of the firm in Somerville.

In the early part of May, 1877, an agreement was made with the Board of Waterworks of the neighboring city, Cambridge, Mass., for the equipment with telephones of a line connecting the principal office of the department in the business part of the city with the works at Fresh Pond, a couple of miles distant.

The idea of using the telephone as a time-saving appliance, and as a means of communicating intelligence, began to spread; and telephone lines put up for business purposes in the city of New York and in Altoona, Penn., closely followed the Cambridge installation.

During the months of April and May, 1877, applications for agencies began to come in with increasing frequency, and the business management was constantly engaged in disposing of exclusive privileges and territorial licenses under the patents, and in meeting the rapidly enlarging demands for telephones.

This was an excellent beginning, since even for private line work it at once became manifest that the telephone — an instrument which any person howsoever unskilled might after a few trials use effectually — was a wonderful convenience, and a great improvement over anything which had gone before; but it was soon perceived that the potentialities of the instrument could never be fully realized, were its employment permanently

restricted to communication in each case between the same two or the same half-dozen stations; and that its scope of action would be illimitably enhanced by making it the medium of unrestricted intercommunication between any number of stations.

This consideration led to the telephone exchange.

The fundamental idea of every telephone exchange, great or small, is that the lines composing it, each leading from telephone apparatus at an outlying station, — the residence or place of business of a user, — shall converge to a central station, where by uniting the ends of any two lines, telephonic communication between their respective out-stations shall be established. Whether there are but two, two hundred, or two thousand customers' wires thus entering the central office, the principle is the same; each, by means of the central station switchboard or commutator, can be connected with the other. Or, ringing the changes upon them, the end of any one may be switched to the end of any of the others whenever required. And since by increasing the number of subscribers' lines to one thousand, ten thousand, or, in fact, any number, the number of possible connections is likewise increased, we may regard the value of the exchange to its patrons as being broadly proportionate to the number of its stations; precisely as the value as an advertising medium of the great city newspaper, with its circulation of half a million, far exceeds that of its village contemporary which prints and circulates but a couple of hundred copies weekly.

While it is the telephone that has made the telephone exchange possible, it is the exchange that has made the telephone indispensable.

Telephone transmission is known to the world mainly through the medium of the telephone exchange; and so immeasurably does the exchange system overshadow all other uses, that in the public estimation the telephone and telephone service are one and the same thing.

The idea of the "exchange" commended itself to Mr. Bell and his associates at a very early day in the history of the telephone as a means for the profitable utiliza-

tion of the invention, and was referred to by Mr. Bell in his lectures of the spring of 1877. The writer of these lines was present at the New York lectures on the evenings of May 17, 18, and 19, 1877, and heard the lecturer outline and eloquently advocate the proposed use of the telephone in the telephone exchange, yet to be developed.

Boston was the scene of the earliest instance of the interconnection on the exchange plan of lines having out-stations equipped with telephones for direct communication between the stations of any two lines; and this occurred in May, 1877. At this time the business of providing electrical protection against burglary was carried on by the Holmes Burglar Alarm Company, and to this company a number of telephones had been furnished for trial and experiment. From the central station at 342 Washington Street, Boston, burglar alarm circuit lines radiated to a number of banks and stores, each line being provided with apparatus at the central point by means of which the burglarious entering of its station might be announced; and arrangements were made for the use of these lines, their sub-stations, and the central station as an experimental telephone exchange. The lines of Brewster, Bassett & Co., bankers (now Estabrook & Co.), the Shoe and Leather Bank, the National Exchange Bank, and the Hide and Leather Bank, together with a new line from the office of Mr. Williams, the manufacturer, were fitted out with telephones and connected at the Holmes central station with a small switchboard made for the purpose. These lines were repeatedly interconnected, and many conversations were interchanged between their stations, the burglar alarm apparatus being employed to transmit the regular call signals. This was in fact the first telephone exchange.

The telephones used by Professor Bell in his lectures were large instruments, in the shape and about the size of the camera of a professional photographer, and comprised a large horseshoe permanent magnet, with short coils of wire on its poles strongly mounted by wooden supports on a baseboard, and an iron diaphragm about four inches in diameter fastened close to the poles on a

perforated wooden block, behind a mouthpiece about three inches long, the whole being covered with a wooden box. The telephones which were made for public use were, however, more portable, and while their working parts remained heavy their cases were made flatter and smaller. No battery transmitters of the variable resistance or microphone type were obtainable during the summer of 1877, or for some months thereafter; and the Bell associates indeed did not advocate or furnish any battery transmitter until the latter part of 1878. The inconvenience of having but a single telephone instrument, and of changing it from the mouth to the ear, or reversely, according as the user was required to talk or listen, soon became apparent, and two magnet telephones, one for speaking and the other for hearing, were then supplied, the former being a modified heavy telephone retaining the large magnet and diaphragm in a large but thin and flat case, which might be fixed at the proper height upon a wall; and the latter in a portable form with flexible conductor attachments, and of a size to be carried in the hand, and placed to the ear for listening purposes only. These were termed "Box" and "Hand" telephones, respectively, and the latter term still survives.

The first hand telephone had a turned wooden casing and handle, a cylindrical bar permanent magnet about four inches long, a spool for its coil about a quarter of an inch long and one and one-eighth inches across, and a diaphragm of ferrotype iron one and three-quarters inches in diameter, and was made in May, 1877. This shape was slightly modified in June, the handle being made plainer in shape, and with a deeper flare at the mouthpiece; and by December, 1877, wood as a material for the handles was given up, hard rubber from that time to the present taking its place. It may in this connection be added that about the middle of August, 1877, the single bar magnet thus far used in hand telephones was discontinued, and a compound magnet formed of several thin laminæ of magnetized steel with a soft iron polepiece was substituted.

Thus made, the hand telephone has remained without further change until a relatively recent period, when, in place of the compound bar magnet, a long U magnet with its poles brought near to one another close to the diaphragm centre has been adopted.

During the month of May, 1877, Mr. Bell and his associates published their first manifesto — a sort of circular advertisement — announcing that they were prepared to furnish telephones and erect lines all over the country, and stating the price and terms. It is noteworthy that this circular asserted the practicality of the instrument for distances up to twenty miles; that it acknowledges that at first the reproduced voice seems indistinct; and that it points out that slight practice only is required for the acquisition of familiarity in the use of the instrument.

From this time forward the work of furnishing telephones and of sending them out for commercial purposes advanced by leaps and bounds. By June 30, 1877, 230 telephones were in regular use. This number within one month had increased to upwards of 750; at the end of August to 1,300; and by the spring of 1880, when the American Bell Telephone Company took over the business, we find in operation, some 61,000 transmitting and receiving telephones. Here it may be remarked, that since magneto telephones only were employed for several months subsequent to the establishment of a regular telephone business, it became customary to count each instrument as a telephone even though there might be two in a single installation, one used exclusively as a transmitter and the other as a receiver. This practice necessarily continued after the general introduction of the variable resistance transmitter, since each instrument contained the invention; and it thus comes about, that even at the present day, each instrument, whether a transmitter or a receiver, is reckoned as a telephone; and that the transmitter and the receiver of each station are counted as two telephones.

By the late summer of 1877 it had become clear that some sort of an organization was necessary to take charge

and properly supervise the commercial development of the telephone, which was assuming dimensions of very considerable magnitude. As a temporary expedient, the owners of Mr. Bell's telephone patents, who at this time were very few, including merely Mr. Bell, Mr. Hubbard, certain members of their respective families, Mr. Thomas Sanders, the gentleman who with Mr. Hubbard had interested himself in the Bell inventions, and Mr. Thomas A. Watson, Mr. Bell's assistant, formed themselves in August of that year into a sort of informal unincorporated association having no capital; to which was given the name of the Bell Telephone Association. It was formed to assist and act in support of Mr. Gardiner G. Hubbard, to whom as trustee the Bell telephone patents had been assigned, in the management of the business relations of the telephone; and in devising the best means for its general commercial introduction.

The commercial establishment of telephone exchanges involved much preparatory work; and it devolved upon the Association thus formed, to devise ways and means for establishing and carrying it on; to supervise as best it might, the inventing, contriving, and arranging of suitable call bells and other signaling apparatus, the development of early switchboards and switches; and to arrange systems of exchange circuits and apparatus generally, and even systems of bookkeeping; for it had already been decided to work mainly through licensed operating individuals or corporations, to whom telephones should be supplied. Since the telephone exchange business was radically new, and therefore something of which the proprietors of the telephone and the prospective operating parties were alike totally ignorant, it was inevitable that the Association was required to plan for the business; and after instructing itself, to impart such knowledge as experimentally or otherwise, up to any point, it might have gained, to its intended colleagues; that is, to those who under its authority had engaged in or who were about to engage in the business of operating exchanges.

There was so much to do, and so much more to think of, plan, and learn, that it is not surprising that notwith-

standing the strenuous efforts of the Bell Association and the little band of Boston experimenters, the year 1878 dawned before the practical establishment of the exchange business anywhere.

The telephone central office system at New Haven, Conn., was opened for business on Jan. 28, 1878, and was the first fully equipped commercial telephone exchange ever established for public or general service.

Of course more was learned about the telephone exchange business, and the questions concerned in the conduct of an exchange, by the practical experience of one brief month, than had been by the previous nine months of speculative consideration; and equally of course, the example of New Haven was speedily followed by other cities, the subsequent installation of other exchanges in the large cities being from this time, and for many months thereafter, a continuous performance, with the result that by March, 1881, within a year after the American Bell Telephone Company began business, there were in the United States only nine cities of more than ten thousand inhabitants, and only one of more than fifteen thousand, without a telephone exchange.

By this time the work of the Bell Telephone Association and its management had become so heavy that the expediency of a more formal and more effective organization of ownership was manifest. The Association realizing the necessity, took its first action in this respect by forming the New England Telephone Company, which was incorporated under the general laws of Massachusetts on Feb. 12, 1878, with a capital of two hundred thousand dollars; and by granting it the exclusive right to use, license others to use, and to manufacture telephones, in the New England States. This company, however, is not, and has no relation to, the New England Telephone and Telegraph Company now operating throughout the major part of New England; the latter being a subsequently created operating company formed by the amalgamation of a number of smaller original licensees.

Attention was next turned to ways and means for extending the use of the telephone throughout the United

States outside of New England; and to this end the Association proceeded to create the Bell Telephone Company, which was incorporated with a capital of four hundred and fifty thousand dollars, July 30, 1878, also under the general laws of Massachusetts.

The annoyances inseparable from inventorship, and which uniformly attend the prospectively successful operation of patented inventions, were now to assail and cluster thickly round the newly-established industry; and a litigation, never again to utterly cease for more than a few months at once, until the expiration of the patents at the close of the term of years for which they were respectively granted, was now to begin.

For seventeen months after the grant of Mr. Bell's original patent for the telephone, no one, publicly at least, disputed his claims to originality; and nobody had asserted, as far as was publicly known, that any one except Mr. Bell had originated any apparatus capable of transmitting spoken words; or had conceived the idea of making the line current similar in form to the sound wave. He came before the world as the first inventor of the speaking telephone, and as such every one had hailed him. He was called upon by learned men to give lectures about and exhibitions of his telephone, and he gave them; and the practical and commercial success of the speaking telephone had been unquestionably attested by the avidity with which the public by this time had taken it up.

But by August, 1877, the Western Union Telegraph Company — a corporation which had established a substantial monopoly in the transmission of intelligence by electricity — appears to have become satisfied of the great commercial value of the speaking telephone, and, engaging in its manufacture and use, set up several rival claimants to its inventorship; proceeding within the following year, in conjunction with its associates the Gold and Stock Telegraph Company, and a new organization which it had formed, the American Speaking Telephone Company, to establish telephone exchanges in many important cities and towns. The Western Union Company was in a good position for this aggressive action. It had

great experience; lines already constructed all over the country; many competent electrical experts; and, during the time between the date of its determination to use the telephone as its own, and that on which it commenced actual business, Mr. Edison, employed for the express purpose, had succeeded in producing an excellent carbon transmitter.

For the rest, it was prepared to ignore the work of Bell, and to appropriate to its own use the art and apparatus he had invented; alleging, of course, that others had done it before him.

The possession of a good battery transmitter counted heavily in favor of the competitor; and for some months which intervened before the Bell Companies could bring their patents to bear effectually upon the situation, it was apparent that they labored under a decided practical disadvantage. But during the summer of 1878 an excellent form of transmitter was invented by Mr. Francis Blake, which, being acquired by the Bell Telephone Company, was commercially introduced towards the end of the year, bringing the parties to the contest into a more nearly equal position.

This was the well-known Blake transmitter. It was a true microphone, and an instrument of remarkable merit, which for sensitiveness and range of adjustment has never been surpassed. It received at once high public favor, and from the time of its introduction until the beginning of the long-line system (when it became gradually displaced by the more powerful, highly developed transmitters of the "Hunnings" or granular carbon type), it was practically without a rival.

The New England and Bell Telephone Companies had the courage to bring suit, in September, 1878, against one Peter A. Dowd, the Boston agent of the Western Union Telegraph Company. But after a good deal of evidence was taken on both sides, the telegraph company became convinced that Bell was the original and first inventor of the electric speaking telephone; and a settlement was effected between the companies on Nov. 10, 1879, under which the Western Union Telegraph Com-

pany and its associates, acquiescing in the original inventorship of Bell, admitted that the Bell telephone patents were good and valid ; and agreed to discontinue the telephone business, and that the telephone inventions they had acquired, the telephones they had made, and the telephone exchanges they had established, should, for suitable compensation, pass under the authority and control of the Bell companies.

Meanwhile, the Bell and New England Telephone Companies had coalesced into a third Boston corporation, which took the name of The National Bell Telephone Company, and came into existence on March 13, 1879, with a capital of $850,000.

The brief, but (for the time it existed) vigorous Western Union competition was a kind of blessing in disguise. At any rate it was not altogether unproductive of results beneficial to the telephone exchange business at large. The very fact that two distinct interests were actively engaged in the work of organizing and establishing competing telephone exchanges all over the country, greatly facilitated the spread of the idea and the growth of the business, and familiarized the people with the use of the telephone as a business agency ; while the keenness of the competition extending to the agents and employees of both companies, brought about a swift but quite unforeseen and unlooked for expansion in the individual exchanges of the larger cities, and a corresponding advance in their importance, value and usefulness.

It may here be mentioned, *en passant*, that the business of producing anticipators of the achievement of Bell thus started, went merrily on for the entire life of the Bell patents ; and although the claimants were all one after another defeated, and the claims of each to prior inventorship promptly proved to be destitute of foundation, the same baseless pretensions were set up over and over again throughout the entire litigation, the parties adverse to the patents in each successive infringement suit introducing not only those that had appeared and been refuted before, but also a new crop of their own ; so that by the time that Bell's patents had run their course, the number

of persons asserted to have invented the telephone before him, and of course each before all of the others, was by no means insignificant. It was the old story, so aptly outlined by Milton: —

> "The invention all admired,
> And each, how he, to be the inventor missed;
> So easy it seemed once found,
> Which yet unfound, most would have thought impossible."

At the close of 1879 the National Bell Telephone Company stood alone, as the proprietor of telephony within the United States, and as the exponent of the telephone business; and the character and prospects of the business having been noised abroad by the litigation and its outcome, there was no longer any difficulty in enlisting all the capital which might be required for requisite extension.

New capital had in fact already been obtained and new blood had entered the counsels of the company. The scope and plan on which the National Bell Telephone Company had been organized were seen to be incommensurate to the expansion already in sight. Accordingly, on March 19, 1880, the American Bell Telephone Company was incorporated by a special act of the Massachusetts Legislature with an authorized capital of $10,000,000, and purchasing the property, took over the business of the National Bell Telephone Company. In conformity with the growth of the business, the American Bell Telephone Company increased its capital from time to time, so that at the end of 1899, the outstanding stock amounted to about $26,000,000. The property and business of the company were then transferred to the American Telephone and Telegraph Company, a separate corporation which it had organized in 1885 to develop the long line business, and the American Bell Telephone Company discontinued its general business.

The history of the telephone exchange is a history of steady and persistent effort and constant and progressive improvement; alike in line work, in central and substation apparatus, and in methods of design, construction, operation, and administration.

As has already been pointed out, one of the great difficulties at the outset of the exchange business was the fact that no one, not even those most intimately concerned in its management, knew anything about it. There was nothing to know. The business was absolutely a new one; everything was experimental; everything had to be learned.

When in the spring of 1880 the American Bell Telephone Company assumed charge of the business, there was no underground construction, and the lines, for the most part of iron or steel, were altogether on roofs or poles.

The telephone circuits were single wire lines with earth returns; cable making was an imperfectly mastered art, and cables crude and untrustworthy; the use of copper line wire was little known and discountenanced; there were no standards in construction and apparatus, every man doing and adopting what might be right in his own eyes.

But under the wise and enterprising supervision, eminent ability and sound judgment of William H. Forbes, the first president of the American Bell Telephone Company, Theodore N. Vail, its first general manager, and John E. Hudson, who succeeded Mr. Vail as general manager and later became president, the business has been gradually systematized, and these imperfections have disappeared.

In the twenty-four years which have elapsed since that time, reliable low capacity poly-conductor cables, mainly employing air as an insulating medium, have been devised and their employment has become universal; underground construction has become the rule instead of the exception; beginning with the year 1883 a metallic circuit system of long distance lines has been built of hard drawn copper wire, and has overspread the country; the average excellency of these long lines, terminating as they do in switchboards at exchange central stations, has resulted in correspondingly improved construction in exchanges everywhere, including the substitution of copper for iron as a material for line wire, and the metallic cir-

cuit for the ground return single-conductor line; the operating companies now have their own buildings specially designed to accommodate the central station operating rooms, and affording facilities for the ingress of the subterranean cables; an elaborate system of protection has been provided for both ends of each telephone line, and where such lines pass through cables, at the cable ends also, to take care of trespassing currents strong enough to be destructive; and lastly, but by no means of least importance, the old and well-known hand operated magneto machine — for years the most approved call-sending apparatus, — and the multitudinous batteries of which one was provided with the transmitter of each user to furnish current for its operation, have both been superseded in the modern well-appointed exchange, by a single central station battery which supplies not only the electric current for all the transmitters of the outlying stations, but also for the transmitters of the central station, and for the switchboard call and supervisory signals. By this change a few cells of battery are enabled to take the place and do the work of many; and the establishment of the few retained cells at the central station where they may always be under skilled supervision is provided for.

These advances which have systematized the technical side of telephony, and which have received the approval of, and have been made available by the foremost telephone engineers in all parts of the earth, are largely attributable to the ability and persevering application of the headquarters' engineering staff; and to the stimulating and encouraging attitude towards practical and meritorious improvement in appliances and methods which has uniformly characterized the Boston management.

Not only is Boston intimately associated with the invention of the telephone and the technical development of the telephone industry, but it remains the centre of the telephonic development of the United States. The courage and far-sightedness of the group of Boston men who at the start put in their money boldly, and worked out plans for a broad and complete development of the

industry, have come down to those still actively concerned in the ever-increasing extension of the network of wires now covering the whole country.

The American Bell Telephone Company, after long years of litigation, found itself confirmed in its patents and in a position to utilize the great invention. But the men who had faith in the value of the telephone as a factor in modern social and commercial life had not been, during these years of litigation, content to accept what was then considered to be the best in this field. On the contrary they worked steadily and patiently to devise means which should make the great fundamental invention more useful and better applicable to all the varying conditions which are met in a modern community.

At the outset an experimental department was established, where problems concerning the clear transmission of speech under varying conditions, the use of cables for telephone wires, and the future employment of underground wires, were given thorough, careful, scientific investigation, always looking towards the end of improving the service and increasing the facilities which the companies might offer to the public. The work was carried on strictly in accordance with the fundamental principle, firmly established in the minds of those interested, that whatever would extend the use of the telephone would be for the benefit alike of the public at large and those who had invested their money.

The numerous telephone companies, not connected with the Bell system, which have sprung up in various parts of the country, have had the advantage of this careful work.

It was but a few years after the invention of the telephone, namely in 1881, that the following statement was made in the annual report of the directors of the American Bell Telephone Company: —

"It will take some time yet to get first-rate service in a large network of towns, as the practical difficulties at least equal those which were met in giving prompt connection within the limits of one city, but nothing but experience and tests of various methods are needed to enable such groups of exchanges to reach satisfactory results."

This quotation shows how plainly the officers foresaw the telephone organization as it exists to-day, a network of companies working together to secure a service as far-reaching as the confines of the United States, with connections extending into other parts of North America.

The original plan upon which the telephone business was started provided for the issuance of a license by the American Bell Telephone Company, the owners of the patents, to use the Bell patents within certain defined territories, the instruments being furnished by the Bell Company. At first these areas were small. Rights were given to use the invention in perhaps a single county, or even a single city; but as time went on it was found that this did not yield the best results, and as early as 1883 we find in the directors' report the following: —

"An important feature has been the consolidation of local telephone interests into large companies covering many counties, and even in several instances the whole or the greater part of entire States."

In 1884 the report of the directors treated this subject more fully: —

"The tendency toward consolidation of telephone companies noticed in our last report has continued, and is for the most part in the interest of economical and convenient handling of the business. The connection of many towns together, causing large territories to assume the character of great telephone exchanges, made it of importance to bring as large areas as possible under one management to insure simple and convenient arrangements for furnishing rapid intercommunication. As methods are devised for making the telephone commercially useful over long lines, the advantages of this centralization of management will be still more apparent, as well as the importance to the public of having the business done in large territories under one responsible head, with far-reaching connections throughout the whole country.

"To make this service of the highest value to the people will be complicated enough under one control. Were it in the hands of many competing companies, the confusion resulting would be very serious, as the value of the telephone will be largely measured by its capacity to give prompt connection with all parts of the country.

"The question of bringing this about to the best advantage is the one to which we have now to address our-

selves. The task is no light one, and it is one in which we have a common interest with the public; and in spite of the prevailing opinion that the development of the telephone substantially under one control is against public interest, we believe that an intelligent examination of this question would demonstrate that this is not true, and that in no other way could the desired results be obtained and the difficulties be surmounted so rapidly and so well as by the present one."

With the movement towards consolidation it was seen at once that large sums of money must be raised for the extension of the business; and in order to aid the operating companies, and at the same time to keep such an interest in them as would enable the owners of the patents to assist in giving the public telephone service, the policy of the company owning the patents was to invest in the stock of the companies operating under licenses, and funds, secured by issue of the stock of the American Bell Telephone Company, were sown broadcast in construction over the whole United States. Almost all of this money was secured from a group of Boston and New England investors, who had faith in the management and the policy outlined.

The result of this policy of investment in local companies has been that the American Telephone and Telegraph Company has at present a financial interest in the telephone business in every part of the United States. It has persistently and steadily worked towards the end that there shall be a system of telephones and telephonic communication so homogeneous in its construction and its methods that, regardless of the part of the country where it may be used, or however distant the point with which communication may be desired, every part of the machinery of administration and operation shall work together harmoniously to give the best possible results to the public.

The American Telephone and Telegraph Company is only in a minor degree an operating company. It has a department which builds and operates the so-called Long Distance lines, whose object is to tie together the lines of the various local companies, and to handle the business

which passes from the territory of one of the operating companies into that of another, and this business is handled from the New York office.

The American Telephone and Telegraph Company, so far as its Boston organization is concerned, acts as an advisory body through which harmony of methods is sought. Its engineering department and its accounting department seek so to combine and consolidate, and study the information received from all of the companies actually operating telephone systems as to produce a system which will be uniform, and which will work smoothly and economically in whatever part of the country it may be used. Standard methods for construction of pole lines, standard types for switchboards and other apparatus, and standard methods of accounting are prepared and presented to the companies operating, not as compulsory methods to be employed, but as methods which, in the judgment of those who have access to the widest possible range of information, have commended themselves as worthy of careful consideration by the workers in the field.

Akin to these plans, by which standard methods are recommended, are the careful studies made by the engineering department, showing the probable lines of telephonic development in large cities. These studies serve as a guide to those in charge of the exchanges at different points. They indicate the proper location for the exchange buildings, and the streets in which underground construction ought to be carried out. In preparing them, the engineers take into consideration the present location of the telephone subscribers, the probable growth in population of the cities, and the geographical direction in which this growth is likely to take place, and their report contains recommendations for underground conduits and cables of sufficient size, laid out upon such lines as will insure future extensions being made upon economical lines. These questions present problems of such vital interest to the companies operating, that the existence of this central organization, which can collate the results of the experience of all those who have seen

the practical side of the problem, is of immense importance to them, both from a technical and financial standpoint.

The flexibility of a system of administration under which a central advisory body deals with problems on broad lines, and allows to local management in the field the adaptation to local conditions of the general conclusions laid down, is one of the factors which has led to the steady and uniform development of the Bell telephone system.

The plan of organization of the Bell telephone system, laid out almost from the beginning of the corporate existence of the company, is simple and elastic. Here in Boston is located the central company, which in the beginning was the owner of the patents and granted licenses for the use of the patented devices, but which has from time to time invested large sums of money in the securities of those companies which actually furnished local telephone service, and in addition has built the long distance lines which bind together the various operating companies.

Then, with general offices located in some thirty-five cities scattered over the United States, we have the operating companies, in which the parent company has a financial interest, and for whose interests it acts as a central advisory body.

Then, beyond these companies, which have this direct connection with the American Telephone and Telegraph Company, lies a group of smaller companies built by local capital and managed by local men, which, by the adoption of uniform methods and the employment of Bell instruments, furnished for a small annual charge, secure connection with the great toll line system of the operating companies and the long distance lines of the American Telephone and Telegraph Company.

In this way it is possible for any small community, at slight expense, to secure the benefits of the great national system of the Bell companies.

Starting in 1884 with the experimental line between Boston and New York, the long distance service has

grown with enormous rapidity, until to-day it reaches over all of the eastern section of the country, meeting the Canadian system at various points on the boundary line, and extending beyond the Mississippi nearly to the western edge of Nebraska. On the south, Jacksonville, Mobile, and New Orleans are reached by these lines, and in the southwest, Dallas. But 140 miles remains to be built to connect the telephone systems of the Rocky Mountains and Pacific Coast with this great eastern system; and, in the northwest, the lines reach Duluth and connect with Canadian lines extending to Winnipeg. Over all these lines conversations are carried on, the longest actually used commercially being the line from Boston to Omaha, which is used every day by one of the large packing houses.

Starting on small lines, groping their way as to the best methods of constructing and operating telephone systems, as to the best plans for rates for service, and as to the best methods for supplying the public demand and dealing fairly with the public, the systems embraced in the various associated Bell telephone companies of the United States have grown with enormous rapidity.

With this growth, there has sprung up a multitude of new uses for the telephone. We find in office buildings and hotels the private branch exchange; in other words, a small exchange connected with the main city exchange by a number of trunk lines, but having its own operator, and having connected to it all the telephones in the building. This allows a smaller number of wires to be extended from the building to the central office, and yet furnishes ample facilities, and at the same time all those located within the building can have communication with one another without taking up the time of the operators at the central exchange.

A striking application of this system is the hotel service, where every guest's room and every department of the hotel is provided with a telephone instrument. Through the private switchboard, located in some convenient part of the hotel, communication can be had not only within the hotel and with all the telephones con-

nected with the city exchange, but by means of the long distance lines of the Bell company a guest at a hotel, say in Boston, may talk with a friend in a hotel in Chicago without leaving their respective rooms.

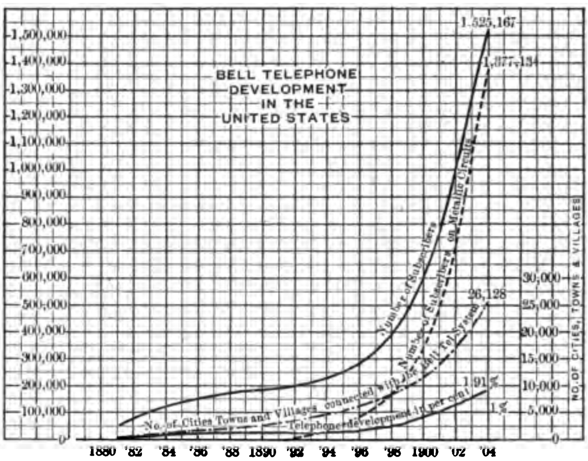
Telephones of special design, adapted for special uses, may be found in mines and on railroad and street railway systems, and in some of the larger and newer houses the older systems of electric bells and speaking tubes have been displaced by a private telephone equipment communicating with every part of the house.

Trains have been equipped throughout their entire length with telephones, so that travellers may converse without the trouble of passing from one car to another; and when the train draws up to a railroad station, by means of a flexible conductor the train system is connected to the local system, so that passengers may talk to their friends in the town, and may even carry on long distance conversations. Steamships are provided with interior telephone systems, and these can also be connected to that of the city when the steamer is lying at the dock.

One of the most interesting fields of the recent development of the telephone has been in the application of the telephone to the railway service. Telephone messages and telegraph messages may be sent simultaneously over the same wire, and at small stations and out-of-the-way points it is no longer necessary to have a telegraph operator, as by the introduction of the telephone on such lines, the station agent may be in constant communication with the train dispatcher and officials at headquarters.

Indeed, the uses to which the telephone may be put are so many that it is scarcely possible to enumerate them here. More important from a social standpoint than any of these mentioned has been the rapid extension of the telephone among the farmers and into the rural districts. In many places farmers have built their own lines into the exchange limits, and placing from ten to twenty instruments on a line, have thus put themselves into close communication with their market towns and

the larger centres of population. The farmers on any individual line are able to converse with one another without calling up the central station, and by means of the central office, often located in a farmer's house and attended by his wife or daughter, these isolated farmhouses can be brought into connection with all the surrounding country. For use in emergences like sickness or fire, for general gossip from one house to another, taking away much of the terror of the isolated existence

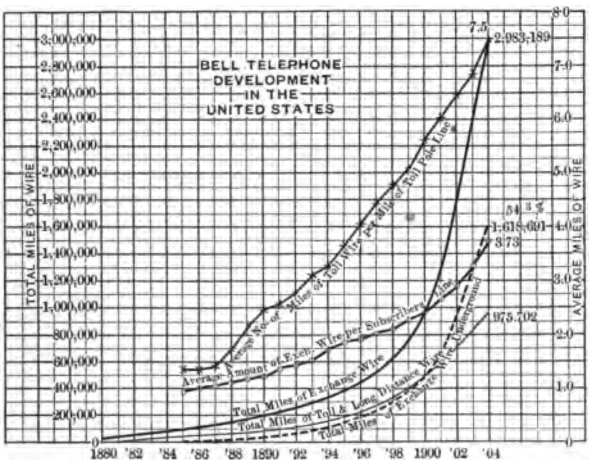


Growth of Connections

on the larger farms of the West, and for the speedy apprehension of criminals and protection against thieves, the telephone has changed the entire aspect of farm life.

From a commercial standpoint, an enormous saving has been made to the farmer by enabling him to receive market quotations for his products, and he has been relieved from the prevarications of the buyer, who formerly made his price to the farmer without regard to the price at the great market centres. Thanks to the telephone, he is not obliged to carry his produce to the market and find it overstocked, for in five minutes he can ascertain whether there is any demand for what he

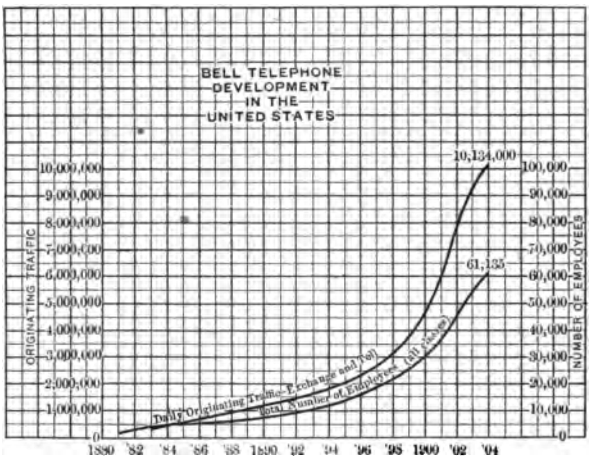
has to sell, or can find, in the case of the great staples like wheat and cotton, whether the prices are such as he is desirous of accepting. He can, moreover, every morning, receive the government predictions regarding the weather for the next twenty-four hours, and when any special warning bulletins of storms or early frosts are sent out from Washington, these, by means of the telephone, are distributed among the farms, and heavy losses are prevented by such timely warnings.



Growth of Circuits

The magnitude of this industry, which, starting here in Boston less than thirty years ago, has spread in that time to all the ends of the world, is well shown by the figures recently issued by the Census Department at Washington, showing the telephone development of the United States at the close of 1902, and including the figures of both Bell and independent companies. There were at that time 2,137,256 subscribers connected with exchange systems, and of these 1,277,983 were subscribers to the Bell system. There were almost 5,000,000 miles of single wire in use in the United States, and over 10,000 exchanges.

But the most significant figures shown were those of the number of messages — 4,949,850,491 exchange messages and 120,704,854 long distance and toll messages, making a total of over 5,070,000,000, of which approximately 60 per cent pass over the lines of the companies making up the Bell system. These figures are more significant in showing the important part which the telephone plays in the life of this country when we consider the fact that the number of letters and post cards pass-



Growth of Traffic and Employees

ing through the United States mail in 1903 was only 5,034,000,000 as against 5,070,000,000 telephone messages, and that in that year the total number of telegraph messages only reached 92,000,000. Judging from the ratio of growth of the Bell telephone companies, the messages transmitted over the telephone lines of the United States during the year 1904 will far exceed the number of letters and postal cards transmitted through the United States mail.

At the date of the last annual report of the American Telephone and Telegraph Company on December 31, 1903, there were 1,525,167 stations in the United States,

and the average number of daily calls per station was six and one-half. That this enormous extension of business calls for vast sums of money is shown by the fact that during the four years from 1900 to 1903 inclusive, the sum of $135,329,700 was added to the telephone construction of the companies making up this Bell system. This sum was divided in the following way: approximately $94,300,000 was used for exchange construction and equipment, $31,400,000 for toll wires, and $9,600,000 for real estate and buildings used for telephone exchanges and offices.

With this vast plant growing out of the invention made by Mr. Bell in 1875 and the enormous use made of it, it is hard to estimate what the saving from an economic standpoint has been to the world at large. We are accustomed to think of the wonderful development of the telegraph system, now double the age of the telephone, and we find it transmitting in the United States 92,000,000 messages a year, while the telephone, in its thirty years, has reached a point where it sends more than this number of messages every week.

It is hard to realize what a modern community would be without the telephone; and to the small scattered villages and the isolated farmhouses the loss of the telephone would be even greater than would be the case if it were to be eliminated from our cities. It would be an inconvenience and a tremendous waste of energy if we were obliged to send messengers or write letters for all of the thousand and one things for which we use the telephone, or to spend our own time in walking around the streets and making useless journeys, finding people not at home, but in the city we could get along. But to the people who are scattered all over the country, where the absence of the telephone means long delays, it is impossible to make any statement in figures which in any way shows the value to everybody of this invention.

The telephone is unique in one feature, — the persons who use this means of communication are brought together in such a way as to enable them to transmit their messages themselves; there is no giving the mes-

sage to some one to send — the very tones of the voice are reproduced at the distant point and are easily recognizable. It is as if we were actually listening with eyes shut to some one speaking. The simplicity of the use of the telephone makes it possible for any one who can speak to use it: it can transmit any language, and is as available for the Chinaman or the Turk as for the Englishman or Italian. There is no need for transforming Oriental languages into conventional letters, as is the case with the telegraph, nor for skilled employés to transmit the message. The messages are spoken by the sender and heard by the receiver, and there is no intervention by any one.

From its earliest conception down to the present day, Boston has been the heart of the telephone industry, from which there has spread not only throughout the United States but throughout the world, this wonderful means for bringing people separated from one another by long distances or by physical disability into instant communication, allowing the exchange of business and social communications, and revolutionizing the social and commercial life wherever it has been introduced.

That the field is covered at the present time no one hints. Vast sums of money are necessary to complete the extension of the present Bell system, but the time will come when every dwelling and place of business in the country will regard the telephone as essential for every-day life as is artificial light. When every household is provided with a telephone it will then begin to be time to talk of the saturation of the population with telephone facilities, but not until this stage is reached.

The nearer this point of saturation is reached the more evident it will become that in the very nature of things the telephone systems must be so allied and connected as to furnish one system. It is impossible to conceive that a means of communication, which owes its value to the number of persons which it can reach, can be of the highest value to all the people when some telephones are connected to one central system and others to a different one. The full development of this

means of communication can only be reached when one great national system has been created — when each and every user can reach every one who has a telephone. Then and then only can this invention, created in Boston and built up here to its present condition, secure to the public the full value of the work of Alexander Graham Bell.

New England Telephone and Telegraph Company

ONE of the largest companies in the United States, constituting a part of the American Bell Telephone system, is the New England Telephone and Telegraph Company, which has its principal executive office in Boston, and operates the exchanges and toll lines in Maine, New Hampshire, Vermont, and Massachusetts, serving an aggregate population of 4,255,000.

The operating companies coördinated with the American Telephone and Telegraph Company undertake the colossal work of organizing the telephone service of the country. Their success is witnessed by the immense volume of business done annually and the prodigious network of wires that now reaches almost every corner of the United States. The work in New England alone is comparable with that developed in the territory of one of the Great Powers.

The Company was organized in 1883 by the consolidation of several local companies which had constructed exchanges in many of the more important cities and towns, and while others of the American Bell companies cover a wider area and serve a larger population, no section of the country presents more varied conditions, or has furnished a more interesting field for the development of the telephone industry than this portion of the New England States.

Maine has its lumbering and manufacturing interests its fisheries, quarries and lime kilns, its ship-building plants, and grand stretch of sea-coast; New Hampshire, aptly designated "The Granite State", has cotton and

woolen mills, and its beautiful mountain scenery, which attracts a summer population from all parts of the United States; Vermont, "The Green Mountain State," also famous for its scenery, has marble and other industries; Massachusetts has its great maritime, commercial, financial and manufacturing interests. While none of these states is looked upon primarily as agricultural, each has large and prosperous farming communities, which retain the qualities that have characterized the New England people from the earliest times, of industry, frugality and thrift; communities, too, in which is found a comparatively high degree of education, and a well developed public school system.

When the New England Company was formed, the telephone business was in the earlier stages of its development. Numerous small companies had been established, each operating in a single city or town, or at most in a very limited area, and having toll connections, if any, only to adjacent points. For the most part the lines were iron ground return circuits, the central office apparatus of various types, long since discarded. The American public, especially that portion which represented large commercial and financial interests, had even then, come to recognize in the telephone an important and valuable agent for the conduct of business and

professional affairs, but its use had, to that time, been confined principally to the larger business and industrial concerns and to people of liberal means.

The term which has elapsed since that period has been one of marvellous progress in the telephone business of New England, not only in enlargement of the business, but in improvement of the character of plant, equipment, and methods of operation. At the beginning of that term, the exchange stations numbered about fourteen thousand. The company has now connected with its system of exchanges and toll lines more than ten times that number.

To accomplish the results already attained has not only involved the expenditure of many millions of dollars for extensions of the property, but the frequent rebuilding and replacement of lines and equipment. New and approved forms of central office apparatus have been substituted for that of older and less effective design so fast as improvements in the art have been made; substantially the entire system has been converted from ground return to metallic circuits, and copper wire and cables have been substituted for iron wire to a great extent. More than two-thirds of the entire mileage of wire used by the Company for exchange purposes has

been placed underground, and in the larger cities and towns buildings of fireproof construction have been erected at the centres of underground distribution, especially designed to serve the requirements of the exchanges. In the large exchanges relay switchboards, with central power plants and lamp signals, have been installed, and others of the same character will be erected during this year. Within that time also a system of toll lines has been constructed, connecting the numerous exchanges and toll stations in the four states above named, having a wire mileage of nearly one hundred thousand miles.

The management of the New England Telephone and Telegraph Company has realized that the constant additions which have been made, year by year, to the number of exchange stations have not only been conducive to the stability and strength of the business, but have added materially to the value and usefulness of the service to the whole body of its subscribers; and it has aimed to extend and enlarge the business as rapidly as is consistent with sound business methods, and to bring the service, so far as possible, within the reach of all classes in the community who can use it to their advantage.

To this end not only the best and most economical methods of construction and operation have been made the object of constant study, but also such adjustment and graduation of rates and service as would provide alike for the requirements of subscribers having large business interests and the tradesman or householder of smaller means, whose use of the service is more limited. Under the plan of development adopted by the New England Company, the result has followed that the service within its territory is employed not principally by persons of large means and extended interests, but, to a larger and increasing extent, by those of moderate means, who find it of value in the conduct of business, or a convenience and safeguard in their homes.

The gradual extension of telephone lines to all the towns and villages still left the service of the rural

districts, which contain a large percentage of the population, undeveloped. The plan first adopted to supply this deficiency was that known as the sub-license plan, upon which the New England Company allowed local companies or groups of residents to develop limited sections of its territory, furnishing them Bell telephones at a reasonable annual rental, and connecting their lines with its toll system at some mutually convenient point.

This plan proved successful, but left the problem of rural service only partially settled.

The solution seemed impossible on any reasonable economical basis, until, after much thought and investigation, a new class of service known as the "Farmers Line Exchange Service" was introduced. Under this plan the Company builds and equips the lines and furnishes service through its own exchanges, the stipulations being that there must be two subscribers to each circuit mile, and that the line shall not extend more than six circuit-miles from the exchange centre without mileage charge.

Though put into effect only a few months since, six thousand contracts have already been taken at the new rates, and the demand is increasing.

The management of the New England Telephone and Telegraph Company has always been conservative, and it has, from the first, been its policy to appropriate from its revenue each year an amount sufficient to keep the existing property in effective condition, and to provide for replacement of such portions of the plant as have become unserviceable by reason of use and decay, or destruction by storm, or which have become obsolete by the introduction of new and better forms of equipment. The average rates of depreciation upon the various classes of property, from the causes first named, have now become quite definitely established, and as, with successive years, the property investment has increased, the cost of its care and reconstruction has increased nearly in the same ratio.

During the series of recent years the annual charge for maintenance of the plant, not including new construction, has amounted to slightly more than one-third of the gross revenue from all sources.

At the beginning of the present year, the Company had in operation three hundred and eighty-two exchanges.

The largest exchange of the Company is in Boston, a city of 560,000 people. At the close of 1903, the exchange stations in that city numbered 34,602. In some thirty cities and towns situated within a radius of ten or twelve miles from the centre of Boston, constituting a part of the Boston and Suburban Division, and having an aggregate population of 578,000, there were 18,955 exchange stations. The next exchange in point of size is that in Worcester, Mass., where, in a population of 118,000, there are somewhat more than six thousand subscribers. Among the other large and more important of the Company's exchanges are those in the cities of Fall River, Lawrence, Lowell, and New Bedford, Massachusetts; Lewiston, Maine, and Manchester, New Hampshire, widely known for their textile manufactories; Lynn, Brockton, and Haverhill, whose principal industry is the

manufacture of shoes; Springfield, Holyoke, and Salem, Massachusetts; Portland and Bangor, Maine; Rutland and Burlington in Vermont.

The system of exchanges and toll lines of the Company has now grown to proportions far in excess of what any one conversant with the business, even ten years ago, would have ventured to predict. So extensive has been the development, that there is no town of considerable size within the four states before named, in which the Company has not an exchange in operation, and but few villages or small centres of population whose residents cannot readily place themselves in communication, by means of its exchanges and toll lines, with the people of the neighboring towns, or with far distant places, as their business or convenience requires; while the connection with the long distance lines of the American Telephone and Telegraph Company furnishes the means of telephonic communication with the people of the great West.

The Capital Stock of the New England Telephone and Telegraph Company is,	$21,616,700	
For several years past dividends have been paid at the rate of six per cent.		
For the year 1903 the Gross Revenue was,	6,692,865	
The expenses were,	5,277,725	
Leaving the Net Revenue available for dividends,	1,415,140	
The exchange stations, including those operated by sub-licenses, numbered at the end of the year,	136,089	
Private Line stations,	7,014	
The mileage of exchange wire was,	220,749	miles
" " " toll " "	94,295	"
Average number of exchange connections daily,	606,826	
Average number of toll connections daily,	35,095	

It is estimated that about twenty thousand exchange stations will be added to the above number during the present year.

Harvard University

IN the fall of 1636, the General Court of the Massachusetts Bay Colony voted four hundred pounds to build a school or college. The vote was approved by Henry Vane, then governor of the Colony. A year later, the Court appointed a commission to take charge of the matter. Scarcely had they begun the work of organization and building, when they received a bequest of the entire library and half the remaining property of an English clergyman, John Harvard, who had died in Charlestown (Boston) after a residence in the Colony of about a year. The new school was therefore named Harvard College, and the name of the town in which it was built was changed from Newtowne to Cambridge, as a tribute to the university where many of the colonists had been educated.

In 1650 the General Court drew up for the College the charter under which it is still governed. This document, which established the oldest corporation in the country, now hangs in the librarian's room in Gore Hall. The corporation thus established consists of the President, the Treasurer, and five Fellows. They fill vacancies in their own number, and make all laws, orders, and appointments, subject only to the approval of the Board of Overseers. This body is a descendant of the board appointed by the General Court before the charter of 1650. Its character has changed somewhat at various times. It now consists of thirty members, besides the president and treasurer, five of whom are elected on each commencement day for a term of six years, by a vote of Bachelors of Arts of five years' standing.

In 1642 the first class was graduated, nine in number. In June, 1904, the Bachelor's degree was conferred

on some five hundred candidates in Arts and Sciences; and, all told, there were nearly 1,100 degrees conferred. In 1652, the senior class consisted of one man, and the whole college had, perhaps, twenty students. In the year 1903–4 there were more than five thousand students enrolled in all departments of the University. The original building, which lasted less than forty years, has been succeeded by an equipment covering in all, some five hundred acres of ground. In 1780, the Massachusetts Constitution referred to Harvard as a University. Up to 1783, when medical lectures were first given, it was properly called Harvard College. Now the College is but one, though an extremely important one, of the sixteen departments of the University.

DEPARTMENTS OF INSTRUCTION

There are nine departments of instruction: Harvard College, the Graduate School, the Lawrence Scientific School, the Summer School, the Divinity School, the Law School, the Medical School, the Dental School, and the Bussey Institution (the Agricultural and Horticultural department).

The administration of these nine schools is committed to four Faculties: the Faculty of Arts and Sciences, the Faculty of Divinity, the Faculty of Law, and the Faculty of Medicine.

University Expenses. The total University expenses for the year 1902–3, excluding new buildings, amounted to $1,600,000, and the receipts from student fees about $720,000, or less than one-half of the expenditures. The invested funds amount to about $16,000,000, excluding University grounds and buildings.

FACULTY OF ARTS AND SCIENCES

Harvard College, the Lawrence Scientific School, and the Graduate School, are under the administration of the Faculty of Arts and Sciences, numbering 132, (in 1902–03, excluding other instructors and assistants).

The Summer School of Arts and Sciences is also in charge of a committee of this Faculty.

Admission Examinations. Admission to the College and Scientific School is by examination, according to a system devised to give the candidate all desirable freedom in the choice of studies he offers and to require of the candidates the same amount of preparatory work. In general, entrance examinations aim to bring out what a candidate is qualified to do rather than what he has already done. These examinations are held in June and September in forty cities of the United States, in Germany, Hawaii, and Japan.

In 1902–3, the Faculty of Arts and Sciences provided 240 whole courses and 214 half courses of instruction in various fields. A course represents ordinarily three hours a week in the class or lecture room, and from three to eight hours a week of work outside the class room. Where a course includes work in a laboratory, three hours of such work is usually counted as the equivalent of one lecture and the outside study connected therewith. The method of instruction is largely by lectures, supplemented in most cases by theses and reports, by recitations, conferences, "quizzes," problems, laboratory work, field work, — as the subject demands.

The courses of instruction in any one field are in the immediate charge of a Division Committee.

Six of these Divisions are so large as to require subdivisions into Departments.

The students registered in the three schools administered by this faculty share for the most part freely in the instruction offered by any of its Divisions, insofar as they are qualified therefor; and in many courses may be found College, Scientific School, and Graduate School students working side by side on equal terms. In the advanced courses, the students of the Graduate School predominate, while in the elementary courses the College and Scientific School students are more in evidence.

A student registered in the College usually has as

his objective a general education, is free to choose his courses, and receives the degree of A.B. after the satisfactory completion of 17½ of these courses. This usually occupies four years, although a steadily increasing number satisfy the requirements in three years. The number of students registered in the College during 1902–03 was 2,109.

A student registered in the Lawrence Scientific School has usually some definite scientific or technical objective, and selects one of a number of prescribed 4-year programmes of study, in each of which are laid down the courses required for the degree of S.B. in the chosen field. The number of courses required in the several programmes varies from 20 to 23. This requires four years of substantial work. The number of students registered in the Scientific School was 548 in 1903–04, distributed among the several programmes as follows: — Civil Engineering, 72; Mechanical Engineering, 56; Electrical Engineering, 74; Mining and Metallurgy, 68; Architecture, 40; Landscape Architecture, 16; Forestry, 7; Chemistry, 23; Geology, 4; Biology, 14; Anatomy and Physiology, 35; for Teachers of Science, 13; General Science, 126.

Work in the Graduate School leads to the degree of Master of Arts, Master of Science, Doctor of Philosophy and Doctor of Science. A Bachelor's degree is required for admission. The Master's degree requires the completion with high grades of four courses, ordinarily a year's work. The Doctor's degree requires in most departments at least one year's residence, a thorough knowledge of the entire subject and minute preparation in some special field of the subject. The results of investigation in the special field must be set forth in a thesis. The number of students enrolled in the Graduate School in 1902–03 was 325. They represented more than 110 colleges.

ENGINEERING

The Lawrence Scientific School, founded in 1847, was intended by its chief benefactor, the Hon. Abbott Lawrence, to be a school of applied science, and as such was the second in America; but although instruction in Engineering was begun in 1850, the energies of the school were directed towards pure science. Here, in 1848, Louis Agassiz introduced the laboratory

Engineering Laboratories, Harvard

method of teaching science; here also taught such men as Benjamin Peirce, Asa Gray, Eben Horsford, Jeffries Wyman and Josiah Cooke. On this foundation many of the now independent scientific establishments of the university had their beginnings; but for almost forty years the technical instruction was confined to Civil Engineering in its narrower sense.

The real development of instruction in Engineering began about 1890, when the Lawrence Scientific School, the Graduate School and the College were merged under the Faculty of Arts and Sciences. In 1888-89

a four-year programme in Electrical Engineering was established, in 1893–94 one in Mechanical Engineering, in 1894–95 one each in Mining and Architecture, in 1900–01 one in Landscape Architecture, and in 1903–04 one in Forestry.

These Departments are now all commodiously housed in Pierce Hall, the Rotch Building, and Robinson Hall. In addition to these buildings are the Chemical Laboratory (Boylston Hall), the Jefferson Physical Laboratory, and the Laboratories of the University Museum, instruction in all of which is regularly given to students of Engineering. The electrical engineering students receive not only their instruction in general physics but also that in electrical measurements and in the theory of electricity, from the Division of Physics in the Jefferson Laboratory, the relations between this Division and the Department of Electrical Engineering being very close.

The most distinguishing characteristic of technical instruction at Harvard is its close affiliation with the other arts and sciences; for not only do students registered in the Scientific School, and following a four years' programme in engineering, partake of the instruction offered by other Divisions, but College and Graduate-School students elect and count for their degrees, courses offered by the Division of Engineering. In this latter custom the University expresses its belief in the educational value of most of the engineering courses. In many of these courses, 25 or 30 per cent of the students enrolled are from the College and Graduate School. The only difference between the student registered in the Lawrence Scientific School (for example, an engineering student) and one registered in the College, is in the manner of selecting his courses; the former elects a programme of study chosen by the Division concerned, as requisite to a systematic training in that field (*e.g.*, civil engineering), while the latter elects each course separately.

This close affiliation is considered of great value to the students of both schools. To the engineering stu-

Dynamo Laboratory, Harvard University

dent it gives a breadth of view and wealth of interest quite unusual in technical schools, and to the college or graduate student it often brings the opportunity which turns him towards engineering as a profession.

The McKay bequest of about five million dollars, for Applied Science (especially for mechanical engineering), will become available in five or six years, and will place technical instruction at Harvard on an enlarged foundation.

PROFESSIONAL SCHOOLS

The Harvard Law School was established in 1817. At that time it was the only school of the sort in the country in close connection with a college. In 1883 Austin Hall, the present Law School, was finished and occupied. Professor C. C. Langdell, while Dean of the Law School, practically reorganized it and gave it its present high standard. This he accomplished by introducing a system of thorough examinations, by originating and using the "case system" of instruction, and finally by making the holding of a college degree a requirement for admission. The School has now in the neighborhood of 750 students.

The original purpose of Harvard College was avowedly to train up a learned clergy for the new country. Five of the nine graduates in 1642 went into the ministry, as did a large part of each succeeding class for many years. In June, 1904, there were seven graduates in theology as against five hundred in arts and sciences. The Divinity School is non-sectarian; it could not be otherwise in a university which supports an institution like Phillips Brooks House, where active and strong student religious organizations of all sects and creeds live and work together. Students of all denominations, too, voluntarily attend daily prayers in Appleton Chapel.

There are four schools in the university that take little or no part in the social life of the students in Cambridge. The Harvard Medical School is situated

on Boylston Street in Boston, three miles from Harvard College, in order that it may secure the clinical advantages offered by a large city. The students visit the various hospitals daily, and some fifty of the students a year are drawn into their service. The standard of the school is high, a Bachelor's degree is required for admission, its examinations are severe, and its facilities of all kinds are great. It employs 33 professors and assistant-professors, and 111 other instructors. It has between 450 and 500 students. It is the oldest professional school of the university. Recent gifts of something over two and a quarter million dollars have enabled the Medical School to begin the erection of five new buildings on the corner of Huntington and Longwood Avenues, in Brookline, a suburb of Boston about five miles from Cambridge.

The Dental School is also situated in Boston. It is now on North Grove Street, but it will probably have accommodations, in the course of time, on the site of the new Medical School buildings. The requirements for admission are lower than those for admission to the College, but they are gradually being brought up to the College standard. The programme covers three years, the first year of which is nearly identical with that of the Medical School.

There is also a School of Agriculture and Horticulture, called the Bussey Institution, after its principal benefactor, and designed to furnish instruction in scientific agriculture.

SUMMER SCHOOL

During the long vacation in the summer, a number of short courses are given in Cambridge under the direction of a Committee of the Faculty of Arts and Sciences. These courses, which cover a wide variety of the subjects regularly taught in the College, Scientific School, and Graduate School, are designed for teachers, and are open to all qualified men and women without formal examination. Some may be taken in-

stead of the corresponding courses in the College or Scientific School, and count towards the Bachelor's degree. The courses meet five times a week for six weeks, and each aims to occupy all the student's working time, though there are a few combinations of two courses that may profitably be taken together.

The number of students enrolled during the summer of 1903 was 1,186, exclusive of the members of the Summer Schools of Theology and of Medicine.

The Library, Harvard

THE LIBRARY

This is located in Gore Hall, includes over 400,000, volumes, and is open during term-time every week, day from 9 A.M. to 10 P.M., and Sundays from 1 to 5.30 P.M. In addition to this main library, there are ten departmental and twenty-eight reference libraries, with collections numbering all together over 200,000 volumes. The total is thus more than 600,000 volumes.

THE ASTRONOMICAL OBSERVATORY

The Astronomical Observatory is situated in Cambridge, on the corner of Concord Avenue and Bond Street. The annual income used exclusively for research is about $50,000. The investigations thus far

completed fill fifty quarto volumes of annals, and the distinguished work here carried on has probably done more to give the University an international reputation than any other single portion of its rich contributions to science.

This observatory and that at Kiel, Germany, have been selected by international agreement as centres for prompt distribution of astronomical discoveries.

Besides the station at Cambridge, the Observatory maintains a very important observing station near Arequipa, Peru, and a series of meteorological stations, crossing the Andes.

UNIVERSITY MUSEUM

The University Museum is commonly called the Agassiz Museum, a title which is no more than a just recognition of the services of Louis and Alexander Agassiz. The north wing of the building contains the Museum of Comparative Zoölogy, the Mineralogical and Botanical Museums are in the centre, the Geological Museum, and the Peabody Museum of American Archæology and Ethnology, are in the south wing. There are many exhibition rooms constantly open to the public. The Ware Collection of Blaschka Glass Models of Plants and Flowers has proved particularly attractive to visitors. It consists of some seven hundred models and three thousand sections made from study of the living specimens of a wide variety of plants. The models are made of glass colored by mineral pigments, imitating with striking accuracy every visible characteristic of the plants themselves. They are the artistic handiwork of Leopold (deceased) and Rudolph Blaschka of Germany. When the latter dies, the secrets of this art will probably die with him.

The Botanic Garden. The Botanic Garden, situated at the corner of Garden and Linnæan Streets, Cambridge, and covering seven acres, was established at the beginning of the last century, and was made famous by the work of the late Professor Asa Gray.

The Gray Herbarium, located in the Botanic Garden, is a collection of 350,000 sheets of mounted specimens, founded and largely developed by the untiring energy of Professor Gray. The Arnold Arboretum, a living museum of trees and shrubs, occupies 220 acres of land in Jamaica Plain, about six miles from Cambridge. It is traversed by about four miles of park roads, and is open to the public every day in the year from sunrise to sunset.

The College Yard, Harvard

GROUNDS AND BUILDINGS

The term "College Yard" has been applied since the earliest records to the main quadrangle enclosed by the College buildings. It was originally the plot between Harvard and Massachusetts Halls, but now properly includes the two main quadrangles, though the term is often restricted to the western, and older, of the two.

The oldest of the buildings now standing in the Yard is Massachusetts Hall, which was finished in 1720, and

NOTE. — When the location of a building is omitted, it may readily be found on the accompanying map; from which may also be obtained a rough estimate of the size of each building.

has not since been changed in outward appearance. Harvard Hall, which faces it, was built in 1766 to take the place of the older hall of the same name, which was destroyed by fire on the site of the present building in 1764. It is now devoted to lecture rooms and department libraries. The Colonial buildings in the order of their age are Massachusetts Hall, Wadsworth House (for many years the President's house), Holden Chapel, and Hollis Hall. Massachusetts Hall was then a dormitory. Holden Chapel was given by the wife and daughter of Samuel Holden, M.P., himself a liberal benefactor of Harvard. It was the first building to take its name from an English benefactor. Hollis Hall is named for Thomas Hollis, an English merchant, who, though a Baptist, gave sums, then considered vast, to a college that dismissed its first president because he objected to the baptism of infants. Holworthy Hall was named for Sir Matthew Holworthy, who in 1678 left the College a thousand pounds.

Stoughton and Holworthy Halls, both dormitories, were built in 1804 and 1812, respectively, and University Hall, now the Administration Building, immediately followed Holworthy. The other buildings in the old quadrangle are Thayer, Weld, Grays and Matthews Halls, all dormitories. Dane Hall — the first home of the Law School, is now occupied by the Bursar and the Harvard Co-operative Society. Boylston Hall is the Chemical Laboratory. Here is given all the instruction in Chemistry under the Faculty of Arts and Sciences. It accommodates about 600 students, and contains a Department library of 1,600 volumes. Sever Hall, on the eastern side of the new quadrangle, is the largest building devoted entirely to lecture and class rooms. In Appleton Chapel are held during term-time, daily morning prayers, Sunday evening services, and vesper services Thursday afternoons during the winter months, attendance at all of which is voluntary. These services are conducted by a board of five preachers of various denominations, and the Plummer Professor of Christian Morals.

Phillips Brooks House, situated in the northwest corner of the Yard, was built by subscription in memory of Phillips Brooks, of the class of 1855, Preacher to the University, Overseer, and Protestant Episcopal Bishop of Massachusetts. This building is the home of the various student religious societies of whatever denomination. It contains a large and very attractive reception room, where are held the weekly receptions given by the members of the Faculty and their wives to the students.

Memorial Hall, Harvard

The William Hayes Fogg Art Museum was erected in 1895, at a cost of $170,000. It has an endowment of $50,000. Nelson Robinson, Jr., Hall, the Architecture Building, was erected in 1900–01 at a cost of about $150,000. It has an endowment of about $250,000, and is one of the most thoroughly equipped buildings in the University.

By far the most noteworthy building outside the Yard is Memorial Hall, which stands on the delta be-

tween Cambridge, Kirkland, and Quincy Streets. It was built mainly by subscriptions from graduates, as a memorial to the Harvard men who fought and fell in the Civil War. The Corporation, in accepting it from the graduates, called it "the most valuable gift the University has ever received, in respect alike to cost, daily usefulness, and moral significance." The western end

Physical Laboratory, Harvard

of the hall is the one which is literally in daily use; it serves as a dining hall for some twelve hundred of the students. The eastern end, called Sanders Theatre, is the official assembly hall for all public, and many private academic ceremonies. The building is rich in memorial windows.

Randall Hall, built in 1898–99 at a cost of $100,000, is another dining hall, and accommodates about 1,200 students on the *á la carte* plan at a very reasonable price.

The Hemenway Gymnasium, with a ground plan

area of 15,000 square feet, and a large and varied equipment, accommodates about 2,500 students.

The Jefferson Physical Laboratory accommodates all the University work in Physics. It is 60 by 200 feet, four stories high, well equipped and commodious. A research endowment of $60,000 is well employed in connection with numerous investigations.

Pierce Hall, built in 1901 at a cost of over $200,000, for the Division of Engineering, contains laboratories, draughting-rooms, lecture-rooms, offices, repair-shop, power-plant, and an Engineering Library of more than 6,000 volumes.

The Rotch Building is the old Carey Building for athletics, remodelled and enlarged for the Department of Mining and Metallurgy. It contains metallurgical, ore dressing, and assay laboratories.

The Astronomical Laboratory, housed in a frame building adjacent to the Rotch Building, is entirely independent of the Astronomical Observatory, and is intended entirely for instruction, whereas the Observatory is employed entirely for research.

The Germanic Museum, for the most part the gift of Emperor William II, is temporarily housed in the Rogers building.

The Semitic Museum was finished in 1902, at a cost of about $50,000.

The Stillman Infirmary is a University hospital, beautifully located and with the most approved appointment. Here students and officers are cared for at a moderate price.

STUDENT LIFE

The number of students who live in Cambridge has increased so rapidly of late that the University no longer attempts to feed and house all of them. Memorial and Randall Halls, conducted by student associations, supply with food about half of them. The others patronize restaurants and boarding houses, or avail themselves of their club privileges — now and then

one finds a student preparing his food over a spirit-lamp in his room. At the private boarding houses as, at Memorial Hall, groups of men usually form club tables. The price of board at Memorial Hall is about four dollars per week, at Randall Hall somewhat less, and at boarding houses and clubs usually more.

About one-half of the students room in the College dormitories. Many find quarters in private houses. Others, whose homes are near at hand, live at home, and a still larger number live in private dormitories. Some of these provide quarters neither essentially better nor worse than are provided in the buildings owned by the College. In recent years, however, the enterprise of capitalists has provided very luxurious quarters for the richer students. Most of these are to the south of the College Yard, on Mt. Auburn Street.

The various athletic sports are sustained by elaborate organizations among the students, and are regulated by a committee composed of officers of the University, graduates and undergraduates.

Soldiers Field, the principal college playground, covering 20 acres, was given to the University by Henry Lee Higginson, one of her chief benefactors. On the field are the locker building, the base-ball cage, the base-ball diamond, cricket crease, fields for lacrosse and other sports. The football field and the cinder track are now within the enormous Stadium.

The Stadium comes to the University through the generosity of the Class of 1879, and was made possible by the skill and patience of Professors Hollis and Johnson, of the Division of Engineering. It is a steel and concrete grand-stand, U-shaped in plan, to accommodate some 23,000 spectators at football and other games on Soldiers Field. It can be made to hold 38,000 persons with the aid of temporary structures. It is intended to furnish an economical, fireproof and architecturally pleasing structure in place of the short-lived, dangerous, and unsightly wooden grand-stands hitherto in use.

The developed length of the U at the outside row is

1,390 feet, and the uniform width across from front to back of each wing of the U is 98 feet. The area actually under cover is some 120,000 square feet. The over-all length of the Stadium is 575 feet, and the width is 420 feet, both exclusive of some minor details.

By way of comparison, it may be stated that the corresponding dimensions of the Coliseum at Rome are 616 feet and 510 feet, but the Coliseum had a much greater seating capacity than has the Stadium, owing partly to the fact that in the Coliseum both ends were

The Harvard Stadium

closed and used for seats, and a much smaller space was reserved for the arena.

The highest part of the Stadium now finished is about 53 feet above the ground, but after the upper promenade is roofed in, the final height of the structure will be 71 feet.

In June, 1904, Class Day exercises were for the first time held in the circular end of the Stadium, and proved a marked success.

Rowing is perhaps the oldest of the athletic sports at Cambridge. It began about 1844. Early in the spring there are many races between the class crews, and the various crews of the two boat clubs. From the best of the oarsmen developed in these races the

University crew is finally selected. The crews, and all who wish to row for pleasure, are accommodated in the two boat houses, the Weld and the Newell Clubs on opposite sides of the river near Soldiers Field.

Football was played on the Delta long before the Civil War. The series of games with Yale began in 1875, and with perhaps but one real interruption (1894–97), has been played regularly ever since. The annual Harvard-Yale game draws a larger audience than does any other athletic contest, the attendance at the last such game being nearly 40,000.

Base-ball began at Harvard in 1862, and the series of games with Yale in 1868. In this field Harvard has been very successful, as also in track athletics. At tennis, too, Harvard has turned out players of national reputation. All of Jarvis Field and a part of Holmes Field are now given over to tennis courts which are in constant use all through the season. There are active organizations and teams for playing golf, lacrosse, cricket, and hockey, and there are also fencing and shooting clubs. The Hemenway Gymnasium is uncomfortably crowded every afternoon during the time when outdoor sports are not in season.

Student Publications. The undergraduate publications are now six in number. *The Harvard Crimson* is the college daily newspaper. *The Lampoon*, an illustrated comic paper, and *The Advocate*, a literary magazine, the oldest of the six, are published fortnightly. *The Monthly*, also literary, and the *Harvard Illustrated Magazine* are published once a month. *The Harvard Engineering Journal* is issued quarterly. The editorial boards of all these are self-perpetuating bodies whose records bear many well-known names.

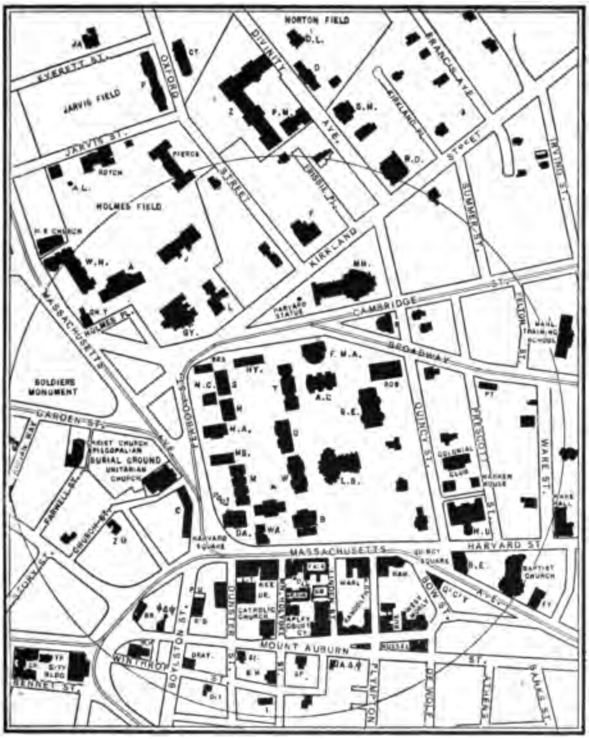
The list of clubs other than athletic is a long one; it would include more than a hundred organizations of various kinds, the history and description of which would make an interesting chapter. They manage the dining halls, and the co-operative store, they are active in religious and political work, they promote Harvard interest in different sections of the country, they carry

on educational work of all kinds, they devote themselves to music, chess, whist, and photography. The most interesting clubs, however, are the more purely social ones. One of the newer ones, but now the most important, is the Harvard Union, originally a debating club, which successfully carried out its purpose to form the nucleus of a University Club like the Unions at Oxford and Cambridge. Major Henry L. Higginson gave the building; other graduates contributed generously in money and effort. The Union is now a handsome, commodious, and well equipped club, membership in which is open to all past and present members of the University at very moderate cost.

The Hasty Pudding Club, probably the best known college club in the country, dates from 1795. Its members originally met in each others rooms to read papers and eat hasty pudding. They still eat the pudding and preserve other traditions, but the literary tradition is almost entirely lost. There are many Greek letter and other societies varying greatly in character, many of them wealthy, with luxurious quarters.

There is a flourishing Engineering Society, with branches in civil, electrical, mechanical, and mining engineering.

Of the student body as a whole there is little to be said. It represents all but a very few elements of American citizenship, with a considerable foreign admixture. One never sees the whole of it at once; but at the great athletic exhibitions and on a few occasions of special academic interest, one may get a fair idea of what the whole would be like.



Harvard University

A.	Austin Hall, Law School, 1883.	Bks.	Phillips Brooks House, 1898.
A. C.	Appleton Chapel, 1858.	C.	College House, 1832.
A. D.	A. D. Club House.	Coop.	Harvard Cooperative Soc.
A.Δ.Φ.	Alpha Delta Phi Club House.	Cr.	Craigie Hall, 1897.
		Ct.	Conant Hall, 1894.
A. L.	Students' Astronomical Laboratory, 1901.	Cv.	Claverly Hall, 1893.
		D.	Divinity Hall, 1826.
Ap.	Apley Court, 1897.	Da.	Dane Hall, 1832.
B.	Boylston Hall, 1857.	Dana.	Dana Chambers, 1897.
Be.	Beck Hall, 1876.	Di.	Digamma Club.

Dr.	Dunster Hall, 1897.	P. M.	Peabody Museum, 1877.
Dray.	Drayton Hall, 1902.	Pierce.	Pierce Hall.
D. L.	Divinity Library, 1822.	P'c'l'n.	Porcellian Club.
Δ.Φ.	Delta Phi Club House.	Φ. Δ. Ψ.	Phi Delta Psi Club.
Ev.	Everett Hall, 1900.	Pt.	Prescott Hall, 1896.
F.	Foxcroft House, 1888.	Q'cy.	Quincy Hall, 1892.
Fair.	Fairfax Hall.	R.	Rogers Building, 1860.
F. H.	Felton Hall, 1877.	R. D.	Randall Dining Hall, 1898.
F.M.A.	Fogg Museum of Art, 1895.	Ran.	Randolph Hall, 1897.
		R'd.	Read's Block, 1886.
G.	Grays Hall, 1863.	Rob.	Robinson Hall, 1901.
Gnt.	Gannett House.	Rotch.	Rotch Laboratory, 1890.
Gy.	Gymnasium, 1879.	Rus.	Russell Hall, 1900.
H.	Hollis Hall, 1763.	S.	Stoughton Hall, 1805.
H.C.	Holden Chapel, 1744.	S. I.	Stillman Infirmary, 1901.
H.P.C.	Hasty Pudding Club Ho.	S. M.	Semitic Museum, 1901.
H. U.	Harvard Union, 1901.	Se.	Sever Hall, 1880.
Ha.	Harvard Hall, 1765.	Sh.	Shepherd Block.
Ham.	Hampden Hall, 1902.	Si.	Signet Club House.
H'ke.	Holyoke House, 1870.	T.	Thayer Hall, 1870.
H'y.	Holworthy Hall, 1812.	Tr.	Trinity Hall, 1893.
I.	Institute of 1770.	U.	University Hall, 1815.
J.	Jefferson Phy. Lab., 1884.	W.	Weld Hall, 1872.
Lit.	Little's Block, 1854.	W. B.	Weld Boat House, 1890.
Lb.	Library, Gore Hall, 1841.	Wa.	Wadsworth House, 1726.
L.	Lawrence Hall, 1848.	Ware.	Ware Hall, 1894.
M.	Matthews Hall, 1872.	West.	Westmorly, 1898.
Mm.	Memorial Hall, 1874.	W. H.	Walter Hastings Hall 1890.
Mn.	Manter Block, 1882.		
Ms.	Massachusetts Hall, 1720.	Wi.	Winthrop Hall, 1893.
N. L.	New Lecture Hall, 1902.	Z.	University Museum, 1860.
P.	Perkins Hall, 1894.	Z. Ψ.	Zeta Psi Club House.
P. H.	Pi Eta Society.		

The Massachusetts Institute of Technology

THE Massachusetts Institute of Technology is characteristically an institution for instruction in practical engineering in its various branches. The original project of Prof. William B. Rogers, its first president, and his co-workers in founding the institution, now nearly forty years ago, was to provide a complete system of industrial education, and that purpose has been, in so far as was possible and in the light of educational advances of recent years, faithfully carried out.

The State of Massachusetts has generously aided the Institute by grants of money and of land, and by an allotment to the Institute of one-third of the national grants to the State made just prior to the foundation and in more recent years. The larger part of the endowment is, however, due to private beneficence. Around that original foundation has grown up what is now the largest technical and scientific school in the United States, and one of the largest in the world.

The aim of the course of instruction is to give a thorough, well-rounded education in the arts, in science, and in the various branches of engineering, and to turn out men who are competent to enter into practical life as engineers, with a training which has given them not only a grasp of facts, but a power of initiative which will stand them in good stead. A high standard of scholarship has been maintained both in the entrance examinations and in the instruction given within the institution, and the curriculum has the reputation of requiring a greater amount of hard and earnest work on the part of students, than is found in any other technical institution of collegiate grade.

By the last catalogue, the number of students in the Massachusetts Institute of Technology is 1,528; and the number of teachers, 227: while the list of graduates has now reached nearly 3,000 in the thirty-six classes which have gone out. It is a body of alumni which, by its professional activity and by its success in practical life, has reflected credit upon the institution and justified the wisdom of the policy pursued by its founder and his

Rogers Building, Massachusetts Institute of Technology

successors. The undergraduate instruction is arranged upon a group system, resulting in thirteen courses, each leading to the same degree of Bachelor of Science, and requiring four years of hard work for its completion. The abbreviated college course of two or three years recommended or experimented with by institutions dealing mainly with the so-called liberal arts, can find no place in the Massachusetts Institute of Technology, for four years is all too short to cover the amount of work required.

In the early years of the Institute, the course in civil engineering was its most important feature, and is still one of the largest of the engineering departments. In its present state of development it covers a wide range of engineering instruction, — topographical engineering, the building of railroads, harbors and docks, municipal engineering, with its requirement of sewers, roads and streets, the building of bridges, building walls and other fixed structures, and the hydraulic engineering which has become of so great importance in connection with electrical enterprises. A special course in sanitary engineering has within the last few years received much attention, differing from the others in its special requirements in chemistry and in biology.

The largest single department in the Institute is that of mechanical engineering, also one of the original departments. This course is intended to train the student in the scientific principles that form the basis of all engineering, and to do this in a thorough and practical manner. Much laboratory instruction, in the ample engineering laboratories, is given in this course, and in its latter part there are special studies in marine engineering, mill engineering, and heating and ventilation.

Mining engineering and metallurgy, in a well equipped special laboratory, receives close attention. The department has never been a large one, but is intended to give the student a thorough training in the departments of science upon which the technical subjects are based, and to give such laboratory instruction as will render the student competent to attack intelligently the problems which arise in the practical pursuit of his profession.

A thorough course in architecture has done sterling work in turning out men who have taken high places in the profession. The course is richer in the engineering instruction necessary to the design of modern buildings than is usual in architectural schools, and the facilities for work on this side of the subject are here unusually good. A recent innovation in connection with this subject, is a course in landscape architecture and design, dealing with that extremely interesting debatable

ground which lies between architecture and civil engineering. A part of the instruction in this course is given in the Arnold Arboretum, which is by far the best collection of trees and shrubs in the country; and the department of civil engineering coöperates directly with the faculty of architecture in making this department of study complete.

Courses in chemistry and chemical engineering occupy a somewhat prominent place in the curriculum. The subject is here taken up both on the scientific and the practical sides, with special reference to fitting the students to enter the field of technical chemistry and the applications of technical chemistry to modern manufactures. To a certain extent the department coöperates with the department of mining and metallurgy, where the subjects naturally overlap, and special technical instruction in the problems arising in the textile industries is made an available feature in the latter part of the course.

Twenty-two years ago the corporation of the Institute established the course of electrical engineering, which has been conspicuous in the subsequent history of the Institute, and has resulted in giving to the profession a large number of electrical engineers competently trained and capable of making their mark in practical life. The Lowell Laboratories of Electrical Engineering, made possible through recent generous gifts, have just been put in working order. They have an exceptionally complete equipment and are thoroughly designed for the training of electrical engineers in the various branches of the art. Not only is the general subject taken up in a thorough and competent way, but especial instruction is given in telegraph and telephone engineering, subjects which are usually relegated to a minor place in technical schools.

In planning the work of the course in electrical engineering, emphasis has been laid from the very beginning on the fundamental importance of physics, mathematics, and theoretical electricity. A large amount of mechanical engineering is also included, an arrangement rendered possible by the interdependent and har-

monious work of the various engineering departments of the Institute. The several departments mutually support and reinforce one another, allowing a specialization of instruction impossible in a smaller college, with a less numerous staff of instructors. The work of the department is also strengthened by lectures delivered before its students by distinguished engineers not connected with the corps of instruction.

Early in the history of the course there was formed a student engineering society, holding monthly meetings throughout the school year, at which papers are presented by the students themselves or, as frequently happens, the meeting takes the form of a smoke talk, an address, not necessarily electrical in character, being given by some man of prominence in engineering. This society also conducts excursions to electrical plants in and near Boston, and its membership is always largely represented in the meetings held under the auspices of the local branch of the American Institute of Electrical Engineers.

Since the beginning of the year 1902–3, the Department of Electrical Engineering has been located in the new Augustus Lowell Laboratories of Electrical Engineering, erected during the summer of 1902. These cover an area of about 45,000 square feet, including a main power and testing floor, 300 feet in length by forty feet in width.

The Lowell Laboratories comprise not only a large and fine laboratory for dynamo-electric machinery, but a standardizing laboratory and a number of rooms for special research, and a well equipped workshop where apparatus can be prepared. The dynamo laboratory is of particular interest as including not only an extensive equipment of machines for experimental purposes, but also the large working plant which supplies power and light for the whole of the Institute.

It is a thoroughly equipped modern power house plus a large engineering laboratory, and as such is a suitable field for giving not only theoretical instruction, but a most practical view of electrical machinery in everyday use. The apparatus in the dynamo room includes nearly every type now in commercial use, besides much appa-

Dynamo Laboratory. Massachusetts Institute of Technology

ratus which has been accumulated in previous years, and which represents the growth of the art. It is the aim of instruction in this laboratory to give the student a thorough practical acquaintance with the various forms of machinery in current use, to train him in testing and in the minute study of performance which is necessary to grasp the peculiarities of the various machines, to give him, in short, a thorough grip of the fundamental principles of machine design and operation.

The power station supplies the Institute with both direct and alternating currents through a pair of large direct-coupled continuous-current machines, and from a double-current generator of 480 kilowatts capacity, driven by a compound condensing engine, operated in connection with a cooling tower. Along one side of the dynamo laboratory runs the set of special rooms for instruction and research, fully equipped for the carrying out of engineering thesis and of serious practical work. There are, besides, admirably equipped rooms for both incandescent and arc light photometry on a practical scale. The Standardizing Laboratory is fully equipped with the latest forms of measuring apparatus and with specialized devices for almost any variety of precise electrical measurement that the engineer can be called upon to perform. It has a large series of electrical standards of various sorts, together with provisions for verifying commercial instruments and standards, and for carrying on the research work, which forms an essential part of the science of electrical measurements.

Now that thesis work is so frequently carried on at a distance from the Institute, a careful preliminary study of the methods and apparatus to be used becomes even more important than where the work is carried out in the laboratories of the institute itself.

In connection with the regular instruction in the standardizing laboratory there is a system of conferences in which general methods of measurement for technical work are discussed, and questions of precision of results and economy of time specially emphasized.

The Electrical Engineering Laboratories are also

called upon to furnish opportunities for instruction to a considerable number of non-electrical engineers, who will later be called upon to decide certain electrical problems in the selection and operation of electrical machinery. While these students do not need the thorough grounding which is essential to the success of the students in electrical engineering, yet it is extremely desirable that they should have sufficient knowledge to bring about the most satisfactory result in any given case. The laboratory work brings out the matter from the operating standpoint, which is that with which many of this class of men will be most directly concerned.

Throughout the laboratory instruction the importance of investigation and research, of contributing to the great fund of technical knowledge, is strongly urged; and for such work the facilities in the Augustus Lowell Laboratories are unusual. The influence upon undergraduate work of a small body of men carrying on original investigation cannot be overestimated in its effect as an inspiration and as tending to give the student that genuine love for his work which must always exist in the man who is to become really great in any profession.

In pure science the Institute is active and well equipped. It is one of the few institutions that is making a serious attempt to further the study of physical chemistry, for which a new research laboratory has recently been completed, equipped with all facilities for chemical and physico-chemical work. This line of study is not one which attracts a large number of students at present, but in view of its importance in reaching the basis of physical and chemical principles, its introduction here is a forward step in scientific instruction.

The course in physics given by the Institute is distinctly a scientific course, aimed directly to meet the requirements of those who intend to enter, for any purpose, upon a career of pure science. It gives a continuous and thorough view of the various branches of physics, and includes mathematical training advanced beyond the general requirements of the purely technical

courses. Special courses within the department have been devised, leading up to the electro-chemical and electro-metallurgical industries. The laboratory of physics is large and well equipped, with ample facilities for the building of special apparatus and for research work in almost any department of the science.

In the realm of pure science also, a most comprehensive and thorough course in biology is given for students who desire to enter it for its own sake or in coöperation with medical or technical studies. It includes careful training in chemistry, physics and modern languages, in the elements of geology, and in those general culture studies which form not a large but an essential part of the curriculum in the engineering courses. The laboratory equipment is unusually complete, and facilities for research are open to those capable of utilizing them.

A special course in geology offers a general education in natural science, together with particular training in geology, which may be of service for general or technical purposes. There is a distinct demand for men who unite a training in geology with a knowledge of geodetic and hydrographic surveying, and a union of these arts, with proper geological instruction, has been specially in mind in building up the geological course at the Institute.

A very interesting department of work, which has now been established more than a decade, is a special course in naval architecture, providing instruction in the theory and methods of ship designing with a view to training students for the work of building up American maritime industries. This department of instruction met prompt recognition from the United States Navy Department, and has been selected by that Department for the professional instruction of officers who are to enter the corps of naval constructors. A special four-years' course has been laid out with reference to their needs, including, in addition to the general training and professional work in the regular line, instruction in the technique of warship design. At this point the naval course touches closely upon electrical engineering, and

facilities are provided for the adequate instruction of officers in these applications of electricity which are important in their professional work.

A Graduate School has recently been established, enabling students, who, for professional reasons or in the course of study for a higher degree, so desire, to carry on their work beyond the point provided for in the undergraduate curriculum. The introduction of graduate instruction is specially important, as being the basis upon which important researches are likely to be built up, and it is the policy of the Institute to encourage post-graduate study and to provide unusual facilities for those following these higher courses.

In connection with the departments of civil engineering, mining engineering, and architecture, summer schools are held, not necessarily located at the Institute itself, but carried on at whatever points seem necessary in order to keep in close touch with the practical developments of those sciences. At the Institute itself summer courses are provided during the months of June and July which have proved exceedingly useful for students who wish to enter the Institute with advanced standing, and to those who desire training in certain departments of science.

Aside from its laboratories, the Institute is provided with a most efficient library system, including in all some 64,000 volumes, and especially rich in works upon applied science. These collections are, mainly, aside from the general library, which is largely composed of standard reference works, department libraries located in the various centres of instruction for the different departments, and thoroughly accessible to the student. The library is a working library in every sense of the word, and the facilities for promptly getting at the necessary books are here exceptionally good.

The Institute has not had a long career, as measured against some of the older institutions in the country, but it has pursued with a single mind the policy which has placed it in the front rank of technical institutions, not only in the United States, but in the world.

The Western Union Telegraph Company

THE Western Union Telegraph Company is the oldest American company in the field, and operates along the various lines of railway all over the United States. From a very small beginning, has increased until at the present time it has a capital stock of $100,000,000, and reaches nearly every hamlet and village in the country.

According to James D. Reid, who was an old-time authority on the early days of the telegraph, the origin of the company is as follows, as regards its New England components: —

F. O. J. Smith, representative to the 26th Congress from the Cumberland Congressional District of Maine in 1839, formed acquaintance with S. F. B. Morse and his telegraph. An experimental line was built in Boston from Milk to School Streets, with a view of interesting the public, but no capital was invested in the scheme in Boston. Smith then began to construct a line from New York to Boston with his own money and that subscribed by his personal friends. The contract for the construction of the work was given to George E. Pomeroy of New York, the line to be of copper wire, twenty-five poles to the mile. The original company was organized under the act of the Legislature of the State of Connecticut in the session of 1845–1846 as the New York & Boston Magnetic Telegraph Co., with a capital of $175,000. The Boston manager was Ira Berry. The Company, however, earned no money, owing to the poor construction of the line and consequent innumerable delays in the transmission of business, and public sentiment grew steadily against it.

In 1848 the New York & New England Telegraph Company came into existence and both of these companies consolidated with a capital of $300,000, under the name of the New York & New England Union Telegraph Co., the articles of association being signed July 1, 1852. On March 1, 1853, the lines of the Rhode Island Telegraph Co. were purchased for $5,000, and in September, 1853, Charles F. Wood was chosen Superintendent.

In 1860 the American Telegraph Company acquired t' e ownership of the stock of the New York & New England Union Telegraph Company, and a lease was signed and afterwards executed, by which the entire property came under its jurisdiction, and was rapidly merged with its own. A few years later this company becáme, in turn, merged with the Western Union.

The Vermont & Boston Telegraph Company was organized November 11, 1848, and in 1850 the line from Boston to Burlington was completed. It was extended a short time afterwards to White River Junction, then to Springfield, Mass., and later to Rouses Point, N. Y. A connection was also secured to Montreal and Ogdensburg. In 1866 Thomas G. Eckert was elected superintendent of the Western Union, and in that year a lease was executed, giving control of all these lines to the Western Union.

In 1848 the Maine Telegraph Company was organized with lines extending throughout the State of Maine, but was absorbed by the Western Union in connection with the United States Telegraph Company in 1866, a concern which was at that time making a fight for the telegraphic supremacy. The American Telegraph Company was duly organized with a capital stock of $200,000, under the laws of the State of New York, and by absorbing the opposition lines, became a powerful concern. It had seven routes from Boston to New York, and four between New York and Philadelphia. At the period of its reorganization in 1859 it had a capital stock of $1,700,000.

Since those early days the network of the company

in the New England States has been steadily growing, cable connections have been acquired, and local lines have been absorbed, until now a remarkably complete system covers the territory. The centre of the New England work is the Boston office, which is very thoroughly equipped as an operating centre and in which is conducted a very large volume of telegraphic business.

The Postal Telegraph-Cable Company in New England

IN America thé telegraph is operated by two private corporations in active competition with each other. The younger of these competitors is the Postal Telegraph-Cable Company, operating in connection with the Commercial Cable Company to Great Britain, France, and Germany; also with the Commercial Pacific Cable to the Orient; and with the Canadian Pacific Telegraphs to Canada.

This system, which is popularly known as the POSTAL, has been in existence twenty years and reaches all sections of the country. In Boston the central station is in the India Building on State Street, nearly opposite the Stock Exchange, and there are now forty auxiliary offices about the city.

The local organization comprises these departments: Receiving, Delivery, Operating, Dynamo, Bookkeeping, District Superintendent, Local Manager, Electrician, Maintenance of Lines, and Supply Store.

The Operating and Dynamo departments are the only ones of special interest where new methods are employed, although the entire station is new.

The Operating room is 72 feet long and 42 feet wide. The main feature of the room is the switchboard, mounted on an oak frame and divided into eight sections, to which are assigned wires leading to the West, the South, the North, the East, local wires, loops, etc. 800 wires are brought from the underground system into the fireproof terminal room in the basement, and from there led to the different sections of the main switchboard. In the rear of the switchboard is the distributing room; here are located eight vertical cable heads with a capacity of 100 wires each.

High tension currents are intercepted by ½-ampere enclosed fuses; and lightning discharges are diverted to earth through arresters carrying mica plates 5 mils. in thickness. A system of iron frames carries horizontal bars fitted with terminals for 10,000 connections, which may be changed at will without disturbing the main system of wiring. All the trunk line conductors, leaders from the operating tables, repeater tables, etc., centre in this room, and find their proper connection with the several sections of the switchboard. Wherever practicable the permanent wires have been soldered to the frames, thus obviating the use of about 20,000 binding posts. By the combined use of flat and round wedges the number of wedges required in the switchboard has been very greatly reduced.

One section of the switchboard is occupied by the annunciator for use in connection with the leased wire service. The board has a capacity of 50 drops. The throwing of a switch in the office of a lessee releases a drop and rings a bell, which continues to ring until the attention of the chief operator is secured. Another section is occupied by a loop board for connecting auxiliary offices to quadruplex circuits. Each section in the switchboard is provided with transfer facilities to every other section; and in addition to this there is a combining board for increasing the transfer facilities between the several sections.

The room is provided with two double-deck repeater tables, 20 feet in length, upon which are mounted 14 quadruplex and 6 duplex sets and 20 sets of single repeaters. In each local circuit a switch is placed for cutting out the sounders of all sets which are repeating through, thus reducing the noise to a minimum. 12 quartette and 5 sextette operating tables are provided with 78 sittings for operators; there being 60 operators employed in this department. By a simple device the tables are so arranged that such quadruplex and duplex sets as are mounted on the repeater tables can be looped down to these operating tables, which are thus made available for duplex or single wire working. The

full equipment of these tables is entirely new and of the latest type.

In the Dynamo room are located three 2-k.w. Sprague motor generators delivering 385 volts for quadruplex working; two 4-k.w. General Electric machines, supplying local currents, and four Crocker-Wheeler intermediate machines. The electric light current supplies a voltage of 115 volts plus and minus, for charging the single trunk lines. By an ingenious arrangement of switches the electric light current can be used to supply all needs of the system when it is desired to shut down the generators. The switchboard in this department is mounted on slate slabs, all connections on the back being made by copper straps. The dynamo leads are carried under the floor in iron pipes enclosed in sheet-iron lined ducts, to resistance coils covered with enamel and mounted on slate slabs on an iron frame, back of the main switchboard. These coils graduate the amount of current for long and short lines and also protect the generators against accidental short-circuiting.

Galvanometers are used for localizing faults in cables and on overhead lines. A recording apparatus with continuously-moving tape makes a siphon record of all signals passing over any of ten circuits selected by the chief operator. This is used for correcting errors and detecting imperfect transmissions.

At one end of the operating room is a distributing counter provided with filing cabinets and desk facilities for the service department, and connected by pneumatic tubes with the receiving and delivery departments on the ground floor of the adjoining building. Here is located a branch telephone exchange, with several trunk lines to the public telephone system, and also a house system connecting the various departments. A master clock in the operating room controls dials in various parts of the plant.

Some Miscellaneous Industries

NO attempt will be here made to catalogue the diversified minor electrical industries of Boston, since they, for the most part, differ in no essential respect from those carried on elsewhere. A considerable amount of capital is invested in them, and the output is of admirable quality and finds a wide sale. A few of the number are somewhat conspicuous by reason of the specialized nature of the output, which has brought it to international knowledge as well as to the home market.

One of the interesting smaller industries is that of the manufacture of electric heating apparatus carried on at present by the Simplex Electric Heating Company of Cambridge. This is the successor in business of a company which had absorbed no less than fourteen heating enterprises of various magnitudes. Up to seven or eight years ago there was practically very little heating apparatus built in this country, and, indeed, it was dubious whether, aside from the manufacture of heaters for railway cars, it was possible to build up a market, both on account of the high price of energy, and on account of the technical difficulties of the situation.

The introduction of insulating enamels has proved to be the key to the heating situation, although the development of apparatus has also been greatly facilitated by the production of wires of special alloy, peculiarly adapted to enamel construction. After the introduction of successful enamels, enabling the temperatures to be carried as high as 300° to 400° Centigrade without seriously imperilling the life of the apparatus, the electric heating business began to take tangible form, and at the present time the output of such goods is very considerable, both in this country and abroad. A large part of the familiar product of

this kind is built at the Cambridge works here referred to. Electric soldering irons, glue pots, and heaters for various industrial purposes have at present found a wide use, and electrical cooking apparatus is a staple article, mostly in the smaller items of construction, although some large electrical kitchens have been fitted up and, where current can be obtained at low prices, have proved to be extremely economical.

One of the very interesting applications of electric cooking is the electric cracker-baking machine, baking crackers by a practically continuous process, and, curiously enough, at a lower price than could be reached by ovens heated in the usual manner with coal, an advantage due to the much higher efficiency in the utilization of heat in the electric apparatus.

To a certain extent electric heaters for rooms have been utilized, although this line of work is at present only at its beginning; and a thousand and one little articles of convenience in household and manufacturing use have been turned out, many of which are familiar on the other side of the Atlantic, and, indeed, on the Atlantic steamship lines.

Another interesting Boston product which has come to be well known in electrical industry is that of the American Circular Loom Company of Chelsea. Originally making tubular woven fabrics, quite devoid of any special electrical use, this company has, in later years, put out a very useful form of interior conduit having as its basis a tubular fabric.

The use of interior conduits of various forms for electric light wiring and similar purposes is rapidly increasing; the old methods of wiring having proved, upon the whole, inferior to those in which the wire is carried in tubing specially fitted for insulating purposes. The special flexible product of the company just mentioned has filled a useful niche in this scheme of wiring, and has become sufficiently well known both at home and abroad to merit special recognition here.

There are, as has already been mentioned, not a few excellent electrical manufacturing establishments in and

about Boston, turning out large quantities of switches, sockets, railway materials, fuses, small dynamos and motors, and miscellaneous goods, which have found their way into every corner of the world; but more than a mention of their active and successful existence is out of place here. It will perhaps be enough to mention one of the most important of the group. This is the Holtzer-Cabot Electric Company, of Brookline, which is one of the oldest electrical manufacturing houses in New England and has carried on for many years a diversified business in manufacturing a large number of electrical specialties and stock articles of such character as have from time to time been required by the development of the art. In the early days of the telephone it was one of the considerable manufacturers of telephonic apparatus, and of late years the company has turned out a large product in small motors and dynamos, particularly those fitted for special uses.

One type of motor which has been from time to time turned out by the Holtzer-Cabot Company is specially worth noting, as now and then extremely useful in the laboratory. This is a synchronous induction motor, made only in small powers, up to perhaps one-eighth of a horse-power, or a little above, but having the distinguished virtue of being an absolutely synchonous machine while running purely as an induction motor. The conditions under which this unusual property of synchronous running can be obtained are such as to forbid the manufacture of large machines of this type, but for operating various apparatus required to run at synchronous speed in the laboratory or in commercial use, these little motors are singularly convenient.

A Boston product which is every year becoming more and more electrical is the blower output of the B. F. Sturtevant Co. One of the pioneers in the manufacture of power blowers and kindred apparatus, it has in latter years found a world-wide market for electrically driven blowers, and has come to be a considerable manufacturer of electrical apparatus for its own use. Fans and pressure blowers directly driven by

motors have come into very extensive use for ventilation and various industrial purposes, and at the present time no small part of the product bears the Boston trademark. It ranges in capacity from the tiny machine requiring hardly more power than an office fan, to the immense wheels capable of coping with the huge ventilating shafts of a great modern building. Of the varied output of the factory it is hardly necessary here to speak; it is enough to point out its importance in the electrical field into which it has made so notable an excursion.

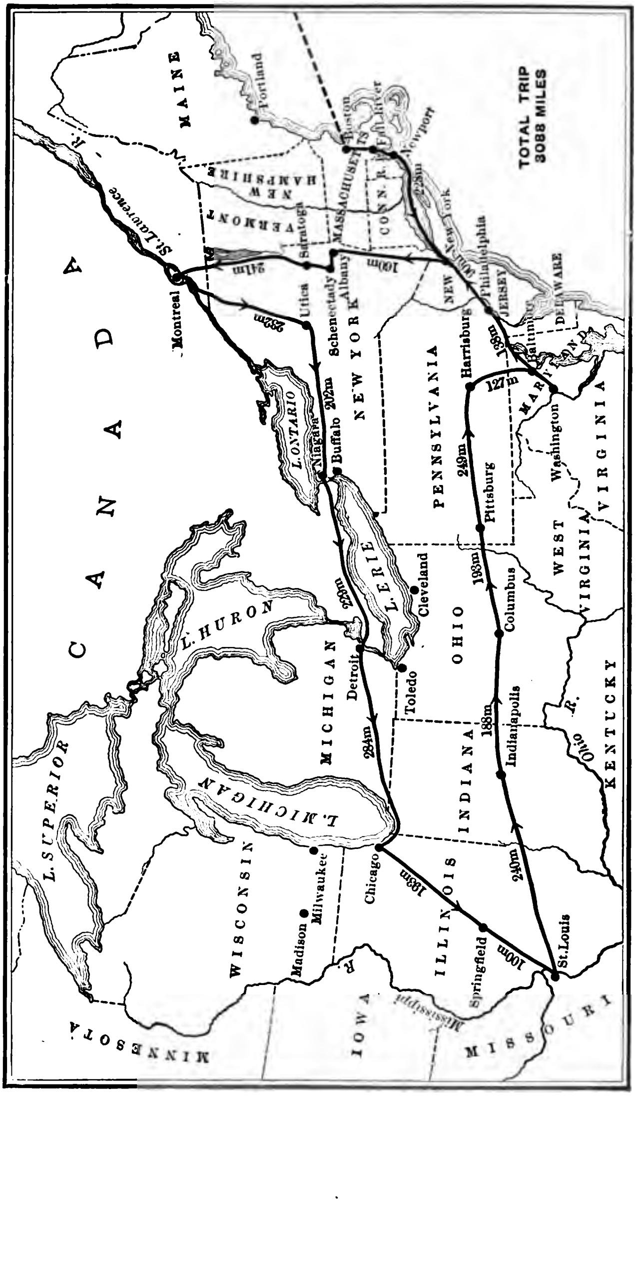
One Boston enterprise in the larger electrical field may perhaps fittingly be mentioned here as of special engineering interest, and that is the Lombard Governor Company of Boston, manufacturer of governors for water-wheels and for steam engines, and of special hydraulic apparatus for use in connection with power plants. The problem of water-wheel governing in the electrical transmission of power from hydraulic plants has always been a serious one.

The requirements of electrical service are so severe that the older types of governor, which proved amply sufficient for running steady loads, for the most part failed miserably when electrical generation was attempted. The necessity for improved governing of water-wheels grew soon to be very acute, and the need for better regulation was fortunately met by the production of the Lombard governors. They are, in effect, sensitive fly-ball governors, in which the moving balls are required only to shift a tiny balanced valve, throwing oil or water under pressure into the working cylinders, and opening or closing the wheel gates with a wonderful delicacy of touch.

Some very ingenious auxiliary appliances are used to prevent hunting, and the upshot of the matter is that the governor actually does control the speed of a water-wheel under varying loads with substantially the same precision that can be attained in a first-class steam engine governor. So signal a success in the solution of a difficult problem is deserving of mention on its

own account, the more so as the governors in question are already known the world over as highly efficient for their purpose.

Space forbids enlarging further upon the electrotechnical industries of the city, those mentioned here being simply worthy types of an activity which has kept New England in the front rank of electrical manufacture since the inception of the industry.


TOTAL TRIP
3088 MILES
C A N A D A
MAINE
NEW HAMPSHIRE
VERMONT
MASSACHUSETTS
CONN.
NEW YORK
NEW JERSEY
PENNSYLVANIA
DELAWARE
MARYLAND
WEST VIRGINIA
VIRGINIA
OHIO
INDIANA
ILLINOIS
MICHIGAN
WISCONSIN
MINNESOTA
IOWA
MISSOURI
KENTUCKY
L. SUPERIOR
L. HURON
L. MICHIGAN
L. ERIE
L. ONTARIO
St. Lawrence R.
Ohio R.
Mississippi R.
Portland
Boston
Newport
New York
Philadelphia
Baltimore
Washington
Harrisburg
Pittsburg
Columbus
Indianapolis
St. Louis
Springfield
Chicago
Milwaukee
Madison
Detroit
Toledo
Cleveland
Buffalo
Niagara
Utica
Saratoga
Schenectady
Albany
Montreal
282m
202m
241m
100m
228m
100m
138m
127m
249m
193m
188m
240m
100m
188m
284m
220m

Itinerary of the Tour

AS already set forth in the circular from the American Institute of Electrical Engineers, this Institute has extended an invitation to the Institution of Electrical Engineers of Great Britain to visit the United States and to hold a joint meeting with it in St. Louis in connection with the International Electrical Congress. A general invitation has already been extended to various European electrical engineering societies to join with the American Institute in a circular tour, visiting important industrial centres, and including the International Electrical Congress at St. Louis, September 12 to 17, inclusive. The programme of this tour is as follows: —

The visiting members of the Institution of Electrical Engineers will arrive in Boston on the White Star S. S. "Republic" on September 2d, and there be met by the local reception committee and by a considerable body of visiting engineers, both foreign and American. Boston is, then, the starting point of the tour, the itinerary of which is sketched on the accompanying map, and has been planned as follows. The entire tour will be by special train, so that the itinerary is independent of the regular railroad schedules.

BOSTON, SEPTEMBER 2d AND 3d

The local reception committee will meet the visitors upon their arrival, and conduct them to the Hotel Vendome, Commonwealth Avenue, which will be their headquarters during their stay in the city. On the evening of September 2d an informal reception of welcome will be given at the hotel. The next morning, in accordance with the special entertainment programme, automobiles will be in readiness for a visit to the power

houses and other points of electrical interest in the city, and a trip through some of the suburbs and part of the park system of the city, reaching Cambridge in time for an informal reception by the corporation of Harvard University, and lunch served at the Harvard Union. In the afternoon the party will return to Boston in time to make a brief visit to the Massachusetts Institute of Technology and other points of local interest, and at 5.45 P.M. the party will leave by train for Fall River, where it will meet the Fall River boat for New York.

NEW YORK, SEPTEMBER 4th AND 5th

The party will reach New York about 7.30 on Sunday morning, September 4th. No special headquarters has been arranged at any New York hotel, owing to the wide diversity of accommodations to be found in the city; but the local committee will take charge of the party, and on the afternoon of September 4th the visitors and all the members of the American Institute of Electrical Engineers will be the guests of Messrs. J. G. White & Co. on a steamboat excursion. On Monday, September 5th, the party, as guests of the New York reception committee, will make a tour of the electrical power stations of New York City and other points of technical interest. In the evening of September 5th a formal reception and dinner will be given to all the foreign visitors by the American Institute of Electrical Engineers.

SCHENECTADY, SEPTEMBER 6th

On the morning of Tuesday, September 6th, the special train will leave the New York station of the New York Central & Hudson River Railroad, beginning the circular tour proper. Starting at 8.45 A.M., the train will run along the east shore of the Hudson as far as Albany, giving views of the Palisades and the famous highlands of the Hudson. About fifty miles from New York, on the west bank of the Hudson, are

the stately buildings of the United States Military Academy at West Point. Leaving Albany, the capital of the state, the train will pass up the Mohawk Valley, and at 12.45 P.M. will reach Schenectady, where are the chief offices and works of the General Electric Company. Here the visitors will be entertained at luncheon by the General Electric Company, and will be shown through the works. Later in the afternoon special high-speed trolley cars will take the entire party to Saratoga, where dinner will be served at the United States hotel. Resuming then the special train, the party will leave at 10.30 P.M. over the Delaware & Hudson Route, along Lake Champlain, and will arrive at Montreal at 7.30 the next evening.

MONTREAL, SEPTEMBER 7th AND 8th

The party will breakfast at the Windsor Hotel, which will be the headquarters at Montreal, and the day will be spent in visiting local power plants and McGill University, at which a reception will be given in the afternoon. In the evening the party will dine as the guests of the Montreal local reception committee, and the next day will start for the many points of interest about Montreal. At eight o'clock in the evening the special train will leave Montreal for Niagara Falls.

NIAGARA FALLS, SEPTEMBER 9th

This point will be reached at nine o'clock in the morning, breakfast being served on the train from 7 o'clock A.M. on. The forenoon will be spent in visiting the Falls and in a trip down the gorge to view the famous Whirlpool of the rapids below the Falls. The party will be the guests at luncheon of the Niagara local committee, and a visit will then be made to the power houses of the Niagara Falls Power Company, the Niagara Falls Hydraulic Power Company, and some of the remarkable electro-chemical works to which power is supplied by those companies. At 6 P.M. the

train will leave Niagara by the Michigan Central Railway, dinner being served on the dining cars en route. This line passes through Canada, and passes into the United States again at Detroit, Michigan.

CHICAGO, SEPTEMBER 10th

Chicago will be reached at 7.30 A.M., September 10th, and during the day the party will be the guests of the Chicago local reception committee, and will visit the power stations and park system and other places of interest. Leaving Chicago by the Illinois Central Railway at 11.45 P.M., the next stop will be Springfield, Illinois, at 7.30 A.M., September 11th. Here breakfast will be served at the Leland Hotel on the arrival of the train, and a trip in the trolley cars will be made to the tomb of Abraham Lincoln. Resuming the special train, St. Louis will be reached at noon, September 11th.

ST. LOUIS, SEPTEMBER 11th TO 17th

On arrival in the city the party will be taken to the Jefferson Hotel, which will be the general headquarters during the stay in St. Louis. An informal reception will be held at this hotel during the evening, and at 9.30 A.M., Monday, September 12th, the International Electrical Congress will open. Its meetings will continue until Saturday, September 17th. At 8 P.M. on this day the special train will leave St. Louis, taking the party to Pittsburg over the Vandalia Route.

PITTSBURG, SEPTEMBER 18th AND 19th

Reaching Pittsburg at 3 P.M., the party will go to the Shenley Hotel which will be the local headquarters. On Monday, September 19th, special trolley cars will be provided for a visit to the Westinghouse Electric & Manufacturing Company at East Pittsburg. After a tour of the works the party will be entertained at lunch by the Company, and in the afternoon a visit will be made to the foundries of the Westinghouse

Airbrake Company. At 9.30 P.M., the special train will leave Pittsburg, and will proceed over the lines of the Pennsylvania Railroad to Washington, where it will arrive at 7.30 A.M., September 20th.

WASHINGTON, SEPTEMBER 20th

Breakfast will be served at the new Willard Hotel, and a visit will then be made to the offices and laboratories of the United States Bureau of Standards, which will on this occasion be formally dedicated. The party will be entertained at luncheon by the Washington local reception committee, and a visit will then be made to the White House and other points of interest. Leaving Washington at 8 P.M., September 20th, the train will reach Philadelphia at 11 o'clock P.M., where the party will have its headquarters at the Bellevue-Stratford Hotel.

PHILADELPHIA, SEPTEMBER 21st

During the morning, visits will be paid to the power houses in the city; and to Independence Hall, and other points of historical interest. The party will be the guests at luncheon of the Philadelphia local reception committee, and a special train will leave Philadelphia that afternoon at 3.30, arriving at New York at 5.30 P.M., and thus concluding the tour, after a journey of more than 3,000 miles.